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FEASIBILITY STUDY OF

CHEMICAL INDUSTRY
IN
SOUTHWESTERN PENNSYLVANIA

PENNSYLVANIA STATE UNIVERSITY
JUL 23 1968
DOCUMENTS COLLECTION

in two volumes

VOLUME 2

Caustic Chlorine
Primary Aluminum Smelter

U.S. DEPARTMENT OF COMMERCE
Alexander B. Trowbridge, Secretary
Ross D. Davis, Assistant Secretary
for Economic Development

ECONOMIC DEVELOPMENT ADMINISTRATION

TECHNICAL
ASSISTANCE
PROJECT

U.S. DEPARTMENT OF COMMERCE

FEASIBILITY STUDY OF CHEMICAL INDUSTRY IN SOUTHWESTERN PENNSYLVANIA

PHASE III

CAUSTIC-CHLORINE

September 1966

"This technical assistance study was accomplished by professional consultants under contract with the Economic Development Administration. The statements, findings, conclusions, recommendations, and other data in this report are solely those of the contractor and do not necessarily reflect the views of the Economic Development Administration."

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I. REPORT IN BRIEF

The preferred site for a caustic-chlorine plant in the Kittanning area is at Reesedale, Pennsylvania, adjacent to the generating station of the West Penn Power Company. The site offers excellent prospects for low cost salt by solution mining and low cost power from a modern station in the immediate vicinity.

The cost of the plant, together with two brine wells, is estimated at $6,604,000. When working capital is added to this figure the total investment becomes $7,454,000.

Based upon merchant sales of chlorine and caustic, and 10,000 tons per year of by-product salt, the plant shows a return of 5.1 percent on investment at full capacity after depreciation. When equity is limited to 20 percent the return on equity becomes 16.7 percent. No credit has been taken for sale of by-product hydrogen or household bleach.

The above plant can operate in the range of 47 to 55 percent of capacity, depending upon financing, and cover all direct operating costs.

This project appears to offer a stable base for the start of a chemical complex in southwestern Pennsylvania.

SINGMASTER & BREYER
By D. R. Whitlock
D. R. Whitlock

II. PROJECT DESCRIPTION

A. PLANT DESCRIPTION

1. Brine Wells

The brine supply for this plant is expected to be supplied by either of two brine wells located within one-half mile of the plant site of the plant proper. The salt strata is expected to be approximately 7000 feet below grade and the salt bed is to be approximately 100 feet thick. Although there is little danger of subsidence, good practice calls for the brine wells to be located away from the plant proper.

The wells should be located at least 1000 feet apart. In operation, a cavity in the salt strata of up to 200 feet in diameter will be developed at each well. At an appropriate time in operation breakthrough to the adjacent well can be achieved, frequently through the application of hydrostatic pressure to crack the strata.

The salt well consists of an outer casing cemented in place. The operating portion of the well consists of two concentric pipes extending to below the top of the salt strata. The inner pipe extends nearly to the bottom of the salt strata. Water is forced under pressure down the annular space forcing brine up the center pipe. Frequently fuel oil (distillate) is injected with the entering water so as to prevent water contact with the top of the salt strata. This preserves the upper layer of salt and reduces the frequency of collapse of the rock strata immediately above the salt strata.

Since both the annular space and the inner pipe are flooded with water or brine, the pressure developed to force brine to the surface is only the difference in hydrostatic head between salt brine and water for the depth of the well.

Brine is collected in a steel tank adjacent to the wells to permit recovery of entrained oil. The oil storage and oil injection pumps are usually located adjacent to the well.

The brine is delivered by pipeline to the brine purification section of the chlorine plant.

2. Brine Purification

The brine for a diaphragm cell chlorine plant is purified by chemical addition to remove calcium as calcium carbonate and magnesium as magnesium hydroxide. Only rarely are brines used which are so contaminated with other materials that this type of treatment is not adequate to provide brine of acceptable purity.

Brine from the wells is collected in a single steel storage tank (approximately 300,000 gallons) holding the brine for at least one day of plant operation. From this tank it is transferred by pump to either of two treatment tanks, each capable of treating brine for one day's operation. Treatment chemicals in the form of sodium hydroxide (cell liquor) and sodium carbonate (carbonated cell liquor) are added and the tank contents stirred. It is important that the sludge remaining in the bottom of this tank be mixed thoroughly with the fresh contents. The tank is allowed to stand for a period of 36-48 hours and the pure brine is then decanted through a precoat filter into the pure brine storage tank. This brine should be sparkling clear and contain specific residual amounts of caustic soda and sodium carbonate. After emptying, the treatment tank can be refilled and the operation repeated.

The brine treatment tanks and associated equipment are so sized that one operator can decant and filter one batch of brine and prepare a second batch for settling during one eight-hour shift.

Periodically, the accumulated sludge in the treatment tanks is diluted with water, suspended and flushed to a disposal area. This material does not make good fill and it is important that it not be allowed to discharge into streams or rivers.

3. Cell House

This chlorine plant has been planned to produce 100 tons per day of chlorine and the associated 111 tons of caustic soda. The cell house will contain 56 Hooker S4 cells operating at 55,000 amperes. These cells may be operated at 60,000 amperes and the production capacity of the plant increased by approximately 9%.

The cell house is arranged with the cells in four rows of fourteen cells each, with all cells connected electrically in series. The cell repair area is located at one end of the cell house. Expansion of the cell house to install additional cells for increased production can be achieved by relocating the cell repair facilities.

The pure brine is pumped through a brine heater into a brine saturator and cell house head tank. This tank provides uniform head and results in constant flow by gravity to each of the cells.

Each cell consists of a concrete and steel box containing vertical graphite plates surrounded by an iron wire mesh screen supporting an asbestos fiber diaphragm. Brine enters the graphite anode space and is decomposed by the passage of electric current. Chlorine moves to the graphite anode, is discharged and released as chlorine gas rising through the brine and leaving from the cell cover. The sodium ions pass through the asbestos diaphragm and are discharged on the iron wire mesh cathode. Sodium promptly reacts with water at this point and releases hydrogen, forming hydroxyl ions. The hydrogen is confined by the asbestos diaphragm and leaves through a vent in the side of the cell. The sodium and hydroxyl ions leave the cell through an overflow connection from the cathode compartment along with undecomposed salt. This mixture of caustic and salt is called cell liquor.

Chlorine and hydrogen are collected in separate headers for treatment to remove water vapor and entrained liquors. The cell liquor is collected in headers and transferred to the caustic evaporation section.

4. Caustic Evaporation

Caustic evaporation is carried out to achieve two purposes: first, to concentrate the caustic to approximately 50% strength so that it can be shipped economically, and second, to remove and recover the salt which has not been decomposed in the cell. Caustic evaporation is usually carried out in triple effect evaporators to achieve optimum heat economy.

Cell liquor is pumped to the third effect of a triple effect evaporator. This evaporator operates at a pressure corresponding to approximately 26 inches of mercury vacuum with the vapor vented to a barometric condenser. In addition to the cell liquor feed, this evaporator also received salt slurry from the second effect evaporator. This effect is heated by the condensing vapor from the second effect evaporator. Salt slurry is transferred from this effect to the slurry tank of the salt recovery system.

The second effect evaporator is fed by clear liquor decanted from the salt slurry tank of the salt recovery system and with the filtrate from the salt recovery system. In addition, the second effect receives salt slurry from the first effect evaporator. The second effect is heated by the condensed vapors from the first effect evaporator.

The first effect is heated by condensing steam in an external heat exchanger. Salt slurry is transferred from the first effect to the second effect. Clear liquor is withdrawn from the first effect and circulated through a flash chamber operating at 26 inch vacuum corresponding to the pressure in the third effect and discharged to the caustic cooling system.

The 50% caustic is cooled by exchange with chilled water to approximately 75°F. The excess salt separates in form of slimes and is removed in a high speed solid bowl centrifuge. The cool caustic contains approximately 1% of dissolved salt and is stored in a large protected metal storage tank. Since the freezing point of 50% caustic is 60°F. this tank contains heating coils.

The salt slurry from the slurry tank is circulated to a solid bowl centrifuge and the filtrate returned to the second effect evaporator. The recovered salt is slurried with salt brine to dissolve traces of sodium sulfate accumulated in the system. This slurry is centrifuged again in a solid bowl machine and collected in a slurry tank for reuse. The brine is reused for sodium sulfate removal until it is nearly saturated with sodium sulfate. The brine is then discarded. Alternatively, the recovered salt may be discharged to a gas-fired dryer, compactor, and the recovered salt bagged for sale.

Equipment in the caustic evaporation and handling systems is usually made of nickel to avoid pickup of iron. It is important that the iron content of the finished caustic not exceed more than about six to eight parts per million.

5. Chlorine and Hydrogen

The chlorine collected in the cell house headers is transferred to a titanium tube chlorine cooler. The cool chlorine passes through a brink demister to coalesce the droplets of brine. Chlorine is dried by direct contact with sulfuric acid in two contacting towers arranged in series. Strong sulfuric acid, concentration 93-98%, is used for drying. Droplets of sulfuric acid are removed in a second demister and the chlorine compressed to approximately 150 pounds in three stages by reciprocating compressors. Chlorine is liquified in a chlorine condenser using water as the cooling media.

Hydrogen, collected in the cell house headers, is vented through vertical stacks equipped with steam lines for snuffing fires when they occur.

6. Storage and Shipping

For this plant, with a production capacity of 100 tons per day of chlorine, we have provided two chlorine storage tanks with a capacity of 500 tons each. These tanks are designed for an operating pressure of 250 psi and are mounted on load cells so that the weight of the contents may be measured directly.

Shipping facilities include one track scale for loading chlorine rail cars and tank trucks.

For caustic storage we have provided two storage tanks containing a total of 30 days production of caustic, and facilities for washing and loading two tank cars simultaneously.

7. Offsite Facilities

This plant must function as an independent unit and be generally self-sufficient with respect to all services and administrative facilities. In our planning for this project we have included an administration building of 3200 sq. ft. area, one story in height. This building will provide offices for the plant manager, production supervisor and chief clerk. In addition, it will contain the laboratory facilities for all chemical test work carried out in the plant. The building will be of concrete block construction, painted inside and out, tile floors, and hung ceilings. The building will be heated but not air conditioned.

The shop building will be contiguous with the warehouse. The building will be approximately 60 feet x 80 feet and of steel and Transite construction.

A change house and lunch room has been located adjacent to the shop building. This building is 40 feet x 100 feet and will provide locker room and wash facilities for all of the hourly staff, and simple kitchen and lunchroom facilities for the entire plant complement. We feel that this site is located somewhat distant from restaurant facilities so that we must make some provisions for food for the staff.

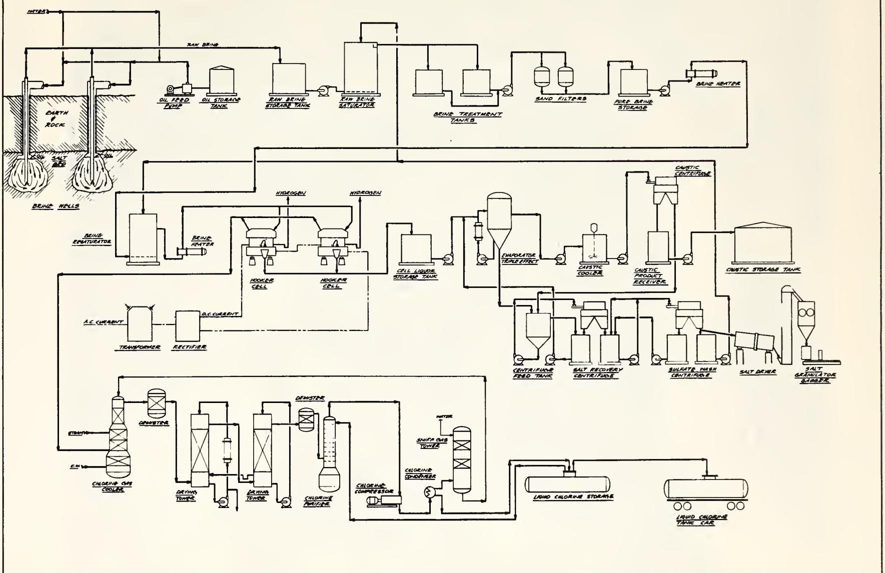
Steam requirements for this plant will approximate 50,000 pounds/hour. A single 60,000 pounds/hour coal-fired boiler has been included with coal storage facilities for one week of operation. The coal supply for this plant will be from local mines with delivery by truck. We have been assured that ample supplies of coal of approximately 12,000 BTU's/pound quality can be obtained, delivered, at $5.50 per ton. This boiler will be complete with feed water treatment and associated facilities.

The plant water supply is planned to be obtained from wells. A fire loop is included surrounding the process area although there will be little in this plant to burn except the coal in storage at the boiler house.

8. Solid Salt Production

As part of the caustic evaporation area we have provided equipment for drying, compacting, and bagging the recovered salt. This is an alternative operation to recycling the salt to the brine system. This equipment has sufficient capacity to process between five and eight tons per hour, corresponding to annual production rates in excess of 40,000 to 60,000 tons per year. This amounts to about half the salt which can be recovered if desired.

We do not visualize that this equipment will be operated continuously. Rather, a campaign basis is planned to replace supplies as they are sold.



SINGMASTER & BREYER
METALLURGICAL AND CHEMICAL PROCESS ENGINEERS

TITLE: CHLORINE PLANT FLOW DIAGRAM

R.K.R

PS-008A-P-1

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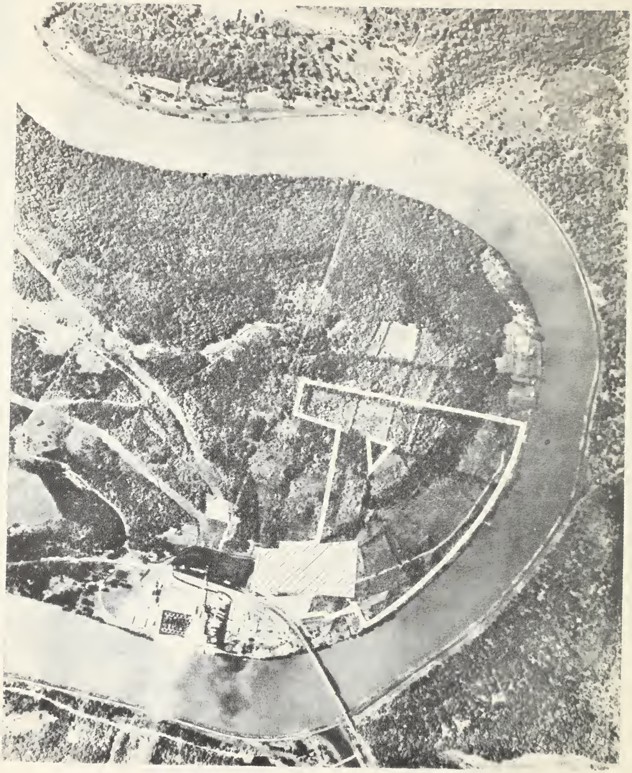
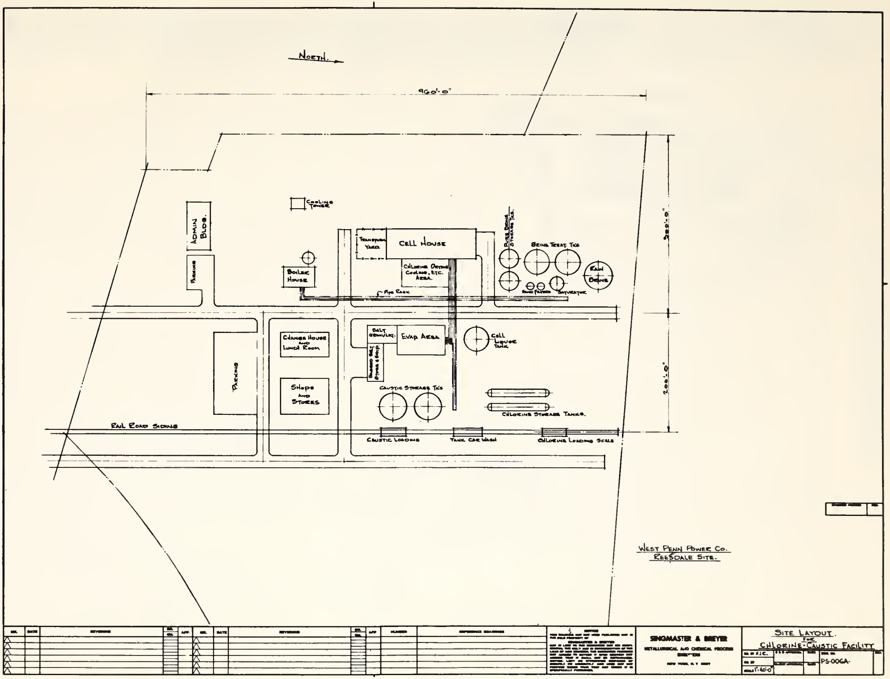


REESEDALE SITE
CAUSTIC-CHLORINE PLANT


NORTH.
960'-0"
200'-0"
200'-0"
COOLING TOWER
ADMIN BLDG.
PARKING
BOILER HOUSE
TRANSFORM. YARD
CELL HOUSE
CHLORINE DRYING, COOLING, ETC. AREA.
PIPE RACK
PURE BRINE STORAGE TKS.
BRINE TREAT. TKS
SAND FILTERS
SATURATOR
RAW BRINE
CHANGE HOUSE AND LUNCH ROOM
SHOPS AND STORES
PARKING
SALT GRANULAT.
EVAP AREA
BAGGED SALT STORE & SHIP
CELL LIQUOR TANK
CAUSTIC STORAGE TKS
CHLORINE STORAGE TANKS.
RAIL ROAD SIDING
CAUSTIC LOADING
TANK CAR WASH
CHLORINE LOADING SCALE
WEST PENN POWER CO.
REESDALE SITE.
SINGMASTER & BREYER
METALLURGICAL AND CHEMICAL PROCESS ENGINEERS
NEW YORK, N.Y.
SITE LAYOUT.
FOR
CHLORINE-CAUSTIC FACILITY
H.J.C.
SCALE 1"=40'-0"
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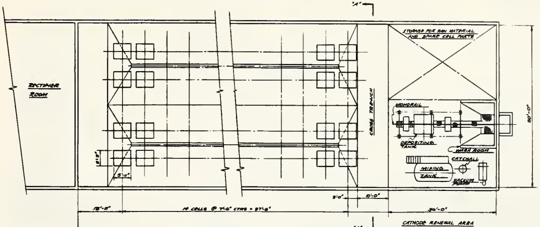
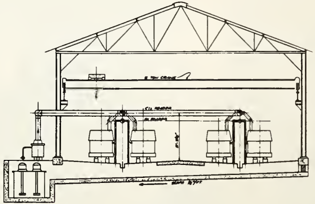


CELL HOUSE
FLOOR PLAN



SECTION "A-A"

SINGMASTER & BREYER
METALLURGICAL AND CHEMICAL PROCESS
ENGINEERS
NEW YORK, N.Y.

100 TONS PER DAY CHLORINE
PLANT - CELL HOUSE

R.K.R.
PS-006A-P-2
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III. CAPITAL ESTIMATE

In preparing this estimate we have found that the greatest area of uncertainty lies in estimating the cost of drilling and fitting-out the brine wells. Well drilling is an uncertain art at best, and without detailed knowledge of the strata below, the best techniques for lowest cost are not likely to be used. For the second well, advantage will be taken of the knowledge gained in drilling the first well. Our estimate is based on actual experience in drilling and operating salt wells within three hundred miles of the site.

Estimates for the cost of the production plant are based on the cost of actual plants, adjusted both for size, location, and time. The estimate has been further corrected by the substation of actual equipment costs where substantial progress has been made in equipment design.

While it is difficult to establish the accuracy of an estimate, we feel that this estimate should be accurate to ± 10 percent over the next six months. Beyond this time appropriate adjustment should be made for price and wage escalation.

CAPITAL ESTIMATE

PLANT CAPACITY -	CHLORINE	100 T/D
	CAUSTIC	110 T/D
	OPERATION	360 D/Yr.
	ANNUAL INDEX TONS	75,300

FACILITIES:		
Land & Site Development		$ 180,000
Roads, Railroads, Cooling Tower, Etc.		535,000
Service Buildings:		
Administration & Lab	115,000	
Change House	126,000	
Shops & Stores	103,000	
Boiler House	380,000	724,000
Brine Wells (2)		500,000
Production Plant:		
Brine Treatment	450,000	
Cell House	1,056,000	
Rectifiers & Electrical	517,000	
Chlorine Handling	602,000	
Caustic Evaporation	2,040,000	4,665,000
WORKING CAPITAL		850,000
	TOTAL	$7,454,000

IV. OPERATING COST ESTIMATE

Power, the largest single item of cost, is based on and interruptible power rate. Present published rates call for \$0.0069 per KWH. We are confident that adequate power can be obtained at a rate of \$0.005 per KWH on an interruptible schedule with a minimum of interruptions. With power at the high rate the index ton cost would increase by \$3.10.

For cell renewal costs we have used cell parts and anode renewal costs based on cell renewal by the Hooker Chemical Corporation from their new plant in Louisiana. Cell renewal requirements for this plant are so low that renewal facilities cannot be justified.

Local coal is readily available by truck delivery at \$5.50 per ton.

Although a market exists for the spent sulfuric acid (78%) used for drying the chlorine, no credit has been taken. This spent acid is suitable for pickling steel. Transportation costs to deliver the acid to the pickling plants will take a portion of the value received for this acid.

Salt well maintenance has been taken at \$150,000 per year to cover anticipated major repairs. Routine maintenance is only a fraction of the costs involved in the repairs due to rock shifts.

The plant personnel are set forth on the following page.

For salt processing we estimate that $3.00 per ton will cover paper bags, fuel for the dryer, and miscellaneous supplies.

DIRECT OPERATING COST

Dollars/Index Ton*

	ITEM AND COST	ANNUAL		INDEX TON	COST
1.	Salt	62,000	Tons	0.825	--
2.	Sulfuric Acid $25/Ton	1,140	"	29	$ .36
3.	Electricity-$0.005/KWH			1620	8.10
4.	Coal - $5.50/Ton	44,000	"	0.585 T	3.22
5.	Misc. Supplies & Chemicals				0.50
6.	Cell Renewal (by Hooker)				3.83
7.	Salaried Personnel	$ 86,640			1.15
8.	Hourly Personnel	195,840			2.60
9.	Contract Maintenance	244,000			3.24
10.	Royalty	19,500			.26
11.	Insurance, Property Tax, Etc.	150,000			2.00
12.	Salt Well Maintenance	150,000			1.99
	TOTAL				$27.25

OPERATING COST AT DIFFERENT OPERATING RATES

Plant Capacity	60%	80%	90%	100%
Annual Index Tons	45,180	60,240	67,800	75,300
Variable Costs--Items 1 thru 6 and 10	$ 735,100	$ 980,000	$1,103,000	$1,225,100
Fixed Costs--all others	826,500	826,500	826,500	826,500
TOTAL	$1,561,600	$1,806,500	$1,929,500	$2,051,600
INDEX TON COST	$34.56	$29.99		$27.25

Salt Processing Cost $3.00 per ton produced.

*Index Ton - A ton of either chlorine or caustic.

PLANT STAFF

A. SALARIED PERSONNEL

Plant Manager	$18,000
Production Supervisor	14,000
Chief Clerk	8,000
Secretary, Telephone Operator	3,600
Plant Chemist	9,000
Chemical Technician	6,000
Master Mechanic	10,000
Janitor	3,600
Total	$72,200
Fringe Benefits-20%	14,440
ANNUAL TOTAL	$86,640

B. HOURLY PERSONNEL

	Number	Category	Annual Cost
Shift Foremen	4	F	$ 38,400
Cell House & Chlorine	4	A	30,240
Caustic Evaporator	4	A	30,240
Caustic Evaporator Helper	4	C	21,600
Brine Preparation	1	A	7,560
Shipping & Loading	3	B	18,720
Valve Testing	1	C	5,400
Cell Maintenance	2	B	12,480
Maintenance Mechanic	2	B	12,480
Relief Operators	3	B	18,720
TOTAL	28		$195,840

WAGE CLASSIFICATIONS:

	Rate	Fringes	Total
Foreman	$4.00/Hr.	$0.80	$4.80
A	3.15	0.63	3.78
B	2.60	0.52	3.12
C	2.25	0.45	2.70

V. FINANCIAL ANALYSIS

A. MARKET

In the caustic-chlorine industry marketing costs, as well as production costs, are greatly dependent upon plant location. From the point of view of available transportation facilities, Reesedale compares satisfactorily with Natrium and Moundsville; product shipment would be by truck and rail transportation on a year-round basis, and by barge, unhindered for nine months out of a year, and occasional delays of up to one week for the other three winter months. Producers at Natrium and Moundsville can ship by barge on a year-round basis.

1. Freight Equalization

In the Oil, Paint & Drug Reporter the price of chlorine is quoted on an F.O.B. works, freight eqalized basis, and the price of caustic soda on an F.O.B. works basis, but with the use of various storage terminals caustic soda is marketed on a "freight equalized multiple basing point system." In addition, sales to paper industry users of chlorine and caustic soda are discounted at 10%.(1) Unfortunately, the principal market for caustic and chlorine from this plant will be plants in the paper industry.

Freight rates to the sites of consumption are very important to the merchant chlorine-caustic producer since the producer bears all freight charges to a particular site which are in excess of the charges from the basing point. The marketing costs that would be distributed to the cost per index ton of product for a producing site depends on the pattern of distribution of the products, i.e., proportion captively consumed and sold without freight equalization charges versus the proportion sold with freight equalization charges. While the marketing costs for freight equalization for the existing producers at Moundsville and Natrium, West Virginia, is indeterminable, a determination of these charges for a Reesedale producer serving the western Pennsylvania area is possible and significant to establishing the feasibility of this location.

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(1) Chemical Weeks, p.21-23, January 9, 1965

a. Chlorine

The rail freight rates are sufficient to establish freight equalization costs for chlorine. Chlorine shipment by truck is rare. The tank carriers serving western Pennsylvania do not have chlorine tank trucks and, in general, very few chlorine producers own them. Chlorine shipment by barge is generally by producers with many distant distribution points who have developed barge shipments to reduce their freight equalization costs.

The table following shows the merchant chlorine market in central and western Pennsylvania that would be served by a plant at Reesedale and the freight equalization costs connected with serving the various consumers.

REESEDALE CAUSTIC CHLORINE PLANT--FREIGHT EQUALIZATION COSTS--CHLORINE

Chlorine Consumption Tons/Year	Rail Frt. Rt. From Present Base Point, $/100 Pounds	Rail Frt. Rate from Reesedale $/100 Lbs.	Annual Savings to Consumers $/Year	Annual Frt. Equalization Cost $/Year
2,550	0.43½	0.40½	1,530	
2,000	0.47½	0.44½	1,200	
8,000	0.58½	0.52½	9,600	
12,500	0.51½	0.64½		33,700
18,800	0.25	0.48½		88,300
43,850			12,330	122,000

Average - $2.78/ton chlorine for 43,850 tons
Minimum - $2.36/ton chlorine for 36,000 tons

The average cost per ton would be reduced if sales to the points farther away were reduced to a greater proportion than sales to the nearer points. Marketing greater than 43,850 tons/year from Reesedale to the present merchant chlorine market would increase the average cost per ton of freight equalization charges.

The minimum freight equalization cost represents 100% saturation of the most economical market. Even the average equalization cost represents 82% saturation of the 43,850 ton market. It is doubtful if either of these can be achieved during the early years of plant operation. We estimate that $4.00 per ton would be a conservative allowance. This cost would go higher during periods of low demand for chlorine and lower during periods of high demand.

b. Caustic Soda

Rail freight charges are also sufficient to establish freight equalization costs for caustic soda. While caustic is frequently shipped by truck, the trucking freight charge is higher than the rail charge since the unit load by rail is greater than that by truck. The table below lists the rail and truck freight charges for caustic between Reesedale and Petrolia, Pennsylvania

	Freight Rate, $/100 Lbs.	
Load	Rail	Truck
70,000 lb. Min.	0.19½	--
40,000 lb.	--	0.23
30,000 lb.	--	0.26

Caustic shipment by barge is generally by producers with many distant distribution points who have developed barge shipments to reduce their freight equalization costs. The table below lists the merchant liquid caustic soda market in central and western Pennsylvania that would be served by a plant at Reesedale and the freight equalization costs connected with serving the various consumers.

REESEDALE CAUSTIC CHLORINE PLANT--FREIGHT EQUALIZATION COSTS--CAUSTIC

Liquid Caustic Consumption Tons 100%	Rail Frt. Rt. From Present Base Point, $/100# Sol.	Rail Frt. Rate from Reesedale $/100# Sol.	Annual Savings to Consumers $/Year	Annual Frt. Equalization Cost $/Year
6,000	0.24½	0.22½	4,800	--
1,025	0.25½	0.22½	1,250	--
6,000	0.27½	0.19½	14,400	--
2,000	0.27½	0.24½	2,400	--
1,500	0.32½	0.28½	2,400	--
7,500	0.28½	0.35½	--	21,000
13,000	0.17	0.27½	--	52,000
37,025				73,000

Average - $1.98/ton NaOH

The freight equalization cost listed is the minimum for 37,000 tons of caustic that would be marketed from Reesedale. A plant at Reesedale producing more than 37,000 tons of caustic annually would have to serve more distant consumers and, therefore, would incur greater freight equalization costs.

As in the case of chlorine, the proposed plant is unlikely to be able to market all of the caustic production within its most economical marketing area. We therefore estimate that freight equalization costs will average, as with chlorine, $4.00 per ton of caustic. This adjustment is somewhat higher than in the case of chlorine to allow for the historically greater difficulty in marketing caustic.

c. Special Rail Freight Rates

Some freight rates for caustic and chlorine to substantial consumers in southwestern Pennsylvania are considerably lower on a ton-mile basis than others. These rates represent the effort of the railroad to retain the substantial business represented by the large volumes being shipped. Conceivably, the producer at Reesedale would eventually develop customers of sufficient magnitude to warrant the railroad to grant a special rate.

2. Market Prices

The average market price for chlorine and caustic is determined by the use to which the caustic is put and by the volume concerned in the particular transaction. The pulp and paper industry has enjoyed a more or less official 10 percent discount for the past six months. This discount has been unofficial for some time previously. While the market for chlorine, and particularly caustic, has been relatively good for the past year, the problem of sustaining two different prices for the same material is serious. There is fear in the industry that the 10 percent discount will spread outside of the paper industry.

Since the plant will be serving both the paper industry and other chlorine and caustic users, the operators will have to maintain the dual price schedule. We estimate that this plant can achieve a balance of sales between discounted and non-discounted users so that an average rate of $59/ton on chlorine and $49/ton on caustic can be achieved before freight equalization charges.

Long term contracts for balanced mixtures of caustic and chlorine in large quantities will go for substantially lower prices; in the neighborhood of $35-$45/ton of caustic and chlorine respectively. We do not visualize that this plant will be in a position to undertake such contracts unless it is substantially expanded.

3. Future Market

The market for caustic and chlorine has been growing steadily in the United States at a rate of about five percent per year. Much of this growth has been tied to the paper industry and most of the new plants in recent years have been located to supply such new plants. While western Pennsylvania does have paper plants, this industry is not expected to show rapid gains in this locality in the immediate future.

The most promising recent development of particular interest is the use of hydrochloric acid for pickling steel. While this process was developed primarily to utilize a by-product, it has proven to so improve control and reduce acid consumption, that it is being widely accepted. This new use, together with the development of oxychlorination processes to make ethylene dichloride and vinyl chloride, have changed the hydrochloric acid market drastically. From a by-product, waste hydrochloric acid has been converted into a valued material in short supply.

As the steel companies in the Pittsburgh area switch over to hydrochloric acid pickling, this proposed plant will be in an excellent position to convert chlorine to hydrochloric acid for their use. This market for by-product acid will further improve the prospects and feasibility of manufacturing chlorinated solvents, insecticides and similar products producing by-product hydrochloric acid.

4. Shipping Expenses

Normally, special railroad cars are used to move chlorine and 50 percent caustic soda solution. A common practice in the industry is to lease railroad tank cars for the transport of caustic and chlorine from a car leasing company such as General American Transportation Corporation. Charges for these cars are as follows:

Fifty-five (55) ton capacity cars can be leased for a ten-year period at a rate of $195 per month per car with a rebate of 18 cents per loaded mile.

Ten thousand (10,000) gallon capacity cars (31.25 tons of caustic soda) can be leased for a ten-year period at a rate of $180 per month per car with a rebate of 12 cents per loaded mile.

It is estimated that the average chlorine car will have a twenty-five (25) day turn-around period and an average distance between shipping points of 200 miles. On this basis, the average chlorine car utilization is 1.2 fifty-five (55) ton loadings per month requiring 45 cars.

The annual lease payments for the chlorine cars would be $87,750; the annual rail rebate recovery would be $19,500 and the annual net cost for leasing these cars is $68,200.

It is estimated that the average caustic soda car will have a turn-around time of 15 days and an average distance between shipping points of 200 miles. The average caustic car utilization is two loadings a month requiring 53 cars. The annual lease payments would be $104,600; the annual rail rebate recovery would be $25,400 and the annual net cost for leasing these cars is $79,200.

Net Annual Cost for Leasing Product Cars

	Cost Per Year
45 Chlorine Cars	$ 68,200
53 Caustic Cars	79,200
Total	$147,400

5. Market for Salt

Since this plant can produce by-product salt we propose that it be marketed locally. This salt will be satisfactory for removing ice and snow from roads and for most agricultural uses but will not be satisfactory for food purposes.

For road use the usual method for marketing is to supply highway authorities on the basis of competitive lump sum bids covering salt used for road use. The salt is made available in the Fall of the year in vendor's warehouse in the vicinity of the application. Payment is made for the salt actually used during the winter. Usual prices are $11-$13 per ton in 80 or 100 lb. bags.

For the purposes of this study we have estimated the sale at 10,000 tons at an average rate of $8.50 per ton after trucking and warehousing charges of $2.50 per ton.

B. RETURN ON INVESTMENT & CASH FLOW

In previous sections of this study we have shown that the Capital Investment for this plant is estimated to be $7,454,000. The direct operating cost is shown to be $27.25 per Index Ton. Freight equalization costs amount to $4.00 per Index Ton. We have estimated an average selling price of $59 per ton of chlorine and $49 per ton of caustic. For the purposes of this study we have taken selling and administrative expenses as five percent of the gross sales of the plant when operating at full capacity. Salt sales are kept constant at 10,000 tons per year.

The net return for this project at operating levels of 60, 80, 90 and 100 percent of capacity is as follows:

Plant Capacity	60%	80%	90%	100%
Annual Index Tons	45,180	60,240	67,800	75,300
Gross Sales Chlorine	$1,274,400	$1,699,200	$1,905,000	$2,124,000
Caustic	1,155,400	1,540,600	1,740,000	1,925,700
Salt	110,000	110,000	110,000	110,000
TOTAL	$2,539,800	$3,349,800	$3,755,000	$4,159,700
Sales & Administration	$ 202,500	$ 202,500	$ 202,500	$ 202,500
Tank Car Cost (net)	165,000	156,200	151,800	147,400
Freight Equalization	180,700	241,000	271,200	301,200
Salt Shipping & Storage	25,000	25,000	25,000	25,000
TOTAL SALES EXPENSE	$ 573,200	$ 624,700	$ 650,500	$ 676,100
Gross Plant Income	$1,966,600	$2,725,700	$3,105,500	$3,483,600
Manufacturing Cost	1,591,600	1,836,500	1,959,500	2,081,600
Gross Income	375,000	889,200	1,146,000	1,402,000
Depreciation (10%)	660,400	660,400	660,400	660,400
NET INCOME (Before Taxes)	$ (285,400)	$ 238,800	$ 485,600	$ 741,600

Break-Even Point (incl. deprec.) = 71% of Full Capacity
Break-Even Point (w/o deprec.) = 47% of Full Capacity

With the break-even point at 71 percent of capacity we will restrict the discussion of return on investment to operating rates of 70, 80, 90 and 100 percent respectively. However, the fact that this plant can operate at rates as low as 47 percent and cover all costs except depreciation shows great stability.

The return on investment will be determined by the method of financing the proposed project. For the purposes of this study we have selected three different methods of financing. These are as follows·

Case 1. All Equity

Case 2. Equal Equity and Long Tern Loans (5%)

Case 3. An ARA Project:

Equity	20.0%	$1,490,800
Local Development Group	10.0%	745,400
Long Term Loans	25.6%	1,908,200
ARA Development Loan (50% Land, Bldgs., Eqpt.)	44.4%	3,309,600
TOTAL		$7,454,000

Case 1. All Equity

This is the least attractive case and shows the problem of entering the industrial chemical field on even a modest scale.

In all cases the return on investment is the ratio of the net income after taxes and depreciation to the equity portion of the investment, expressed as a percentage.

Operating Rate	70%	80%	90%	100%
TOTAL INVESTMENT	$7,454,000	$7,454,000	$7,454,000	$7,454,000
Net Income (Before Taxes)	(6,400)	238,800	485,600	741,600
Depletion Allowance	--	17,900	19,800	21,600
Corporate Income Taxes:				
Federal	--	100,800	212,400	322,000
State	--	11,000	23,300	36,000
Net Tax	--	111,800	235,700	358,000
Net Income (After Taxes)	--	127,000	239,900	383,600
Cash Flow	654,000	784,400	900,300	1,044,000
RETURN ON INVESTMENT	--	1.7%	3.2%	5.1%

The computation of depletion allowances is complex at best. In this case the value of the sodium chloride can be taken at about $3.00 per ton as brine leaving the well or, since clean salt is available at the evaporator centrifuges, at a value of about $7.00 per ton as rock salt and about $20.00 per ton as granular salt. For the purposes of this study we have taken the value of salt in brine as $3.00 per ton.

By normal criteria this project does not offer sufficient return on investment for all equity financing. In examining the Cash Flow projections it should be kept in mind that electrolytic chlorine technology is well established and the rate of obsolescence of process technology is slow. Probably 50 percent of the chlorine produced in the United States is produced in plants that are substantially fully depreciated.

Case 2. Equal Equity & Long Term Loans (5%)

This case represents the situation of the normal medium size chemical company.

Equity	$3,727,000
Loans	3,727,000
TOTAL INVESTMENT	$7,454,000

Operating Rate	80%	90%	100%
Income (Before Int. & Taxes)	$238,800	$485,600	$741,600
Interest	186,400	186,400	186,400
Income Taxes:			
Federal	9,200	127,900	243,300
State	1,700	14,000	26,700
Depletion Allowance	17,900	19,800	21,600
Net Income (After Taxes)	41,500	156,900	285,200
Cash Flow	701,900	817,300	945,600
RETURN ON EQUITY	1.1%	4.2%	7.7%

The ability of this project to weather adverse business conditions is best shown by the new breakeven point, which, without allowance for depreciation, lies between 52 and 53 percent of design capacity.

At high operating rates, the return on equity has improved. Only at high operating rates is the return of any interest.

By using both depreciation and profits to retire loans the situation becomes more interesting. Not only does the return improve, but funds are available for investment in associated facilities based on processing chlorine to more profitable products.

Case 3. An ARA Project

	Participation	Amount	Int.Rate
Equity	20%	$1,491,000	--
Locan Development Group Loan	10%	745,000	6%
Long Term Loans	25.7%	1,916,000	5%
ARA Development Loan	44.3%	3,302,000	4%
TOTAL INVESTMENT	100.0%	$7,454,000	--
Operating Rate	80%	90%	100%
Income (Before Int. & Taxes)	$238,800	485,600	$741,600
Depletion Allowance	--	19,800	21,600
Interest	272,500	272,500	272,500
Income Taxes: Federal	--	81,600	204,000
State	--	9,700	22,400
Net Income (After Int. & Taxes)	(43,700)	122,800	242,700
Cash Flow	616,700	783,200	903,100
RETURN ON INVESTMENT	--	8.2%	16.3%

Under these terms of financing the project becomes fairly interesting to a small investment group. Although ARA is permitted to loan up to 65 percent of the value of the land, buildings, and equipment, we have used a figure of only 50 percent. Equity as low as five percent may also be accepted. However, we do not feel that such terms should be used for this presentation, nor do we feel that they will be required for financing this project.

While the project shows a slight loss at an operating rate as high as 80 percent, the actual out-of-pocket breakeven point lies at about 55 percent of capacity where all costs are covered except depreciation.

VI. CONCLUSIONS

This study has proposed a 100 T/D chlorine plant to be located along the Allegheny River adjacent to the Reesedale Station of the West Penn Power Company. Geological studies have indicated the probability of salt deposits suitable for solution mining as practiced by Pittsburgh Plate Glass Company at Natrium and Allied Chemical Company at Moundsville, West Virginia.

The site is acceptable and steps should be taken to confirm the presence of salt and the suitability of solution mining. This should be done by drilling a test well suitable for development into a production unit. This test well should be located on property controlled by a local development group to insure that the availability of development work to a prospective plant operator.

Estimates of both capital and operating costs have been prepared. Little discussion appears needed except to point out that the cost of electric power has been estimated at 5 mills based on the expectation of the negotiation of a suitable interruptible rate. The frequency and duration of such interruptions are not expected to interfere seriously with the operation of the plant. Arrangements can be made for the plant to "drop electrolysis load" at substantially no penalty in plant cost. The existing rate for this block of "firm" power would add $3.10 to the cost of each index ton produced, an increase of more than 10 percent.

In the economy of the plant we have taken no credit for the hydrogen produced. At full production this will amount to slightly more than one million cubic feet daily. This gas must be cleaned and compressed into cylinders before use. Usually this is done by gas specialty companies such as the Linde Division of Union Carbide, Air Products Company, or Air Reduction Company, who erect processing plants adjacent to chlorine plants. Where there is a market for the hydrogen these companies will buy the hydrogen as produced on a contract basis at rates ranging from $0.30 to $0.50 per thousand cubic feet. Since this market has not been confirmed, no credit has been taken although it represents a significant potential source of income.

Another potential source of income is the manufacture of laundry bleach for the Pittsburgh market. This market is limited and currently supplied so "breaking into the market" must be considered. Should the project be of interest, this market warrants further investigation.

The economy of this plant is based on chlorine and caustic consumers within a 300-mile radius. The paper mills are the primary market. The steel mills in Pittsburgh offer a significant, but not extensive market for caustic. The market showing the most promise is hydrochloric acid for the new pickling process for steel. Thus far its application in the Pittsburgh steel mills is limited but with its acceptance a good market should develop. This process, together with the oxychlorination process for chlorinating hydrocarbons, has substantially increased the demand for by-product hydrochloric acid. Currently, in many areas of the United States, hydrochloric acid is selling at a price equivalent to the market price for its contained chlorine. Although equipment to convert chlorine to hydrochloric acid is not included in the estimated cost of this plant, the investment is modest (about $100,000) and the operating cost is negligible.

We have shown only modest sales of salt for highway clearing and other purposes. There is reason to believe that the major salt producers will permit minor penetration into this market without offering substantial competition. Any attempt to saturate the local market is likely to precipitate a price war. We are confident that at least 10,000 tons per year of salt can be marketed and that sales can be increased up to 20,000 tons per year without serious opposition.

Financial studies of the project based on various methods of financing show out-of-pocket breakeven points ranging from 47 to 55 percent of design capacity. When depreciation is taken into account as a cost, the breakeven point rises to between 70 and 80 percent. Return on equity is modest even under favorable financing arrangements. Cash flow is substantial even under conditions of reduced output.

This project represents a stable base for a chemical operation which is favorably located with respect to competition. Favorable growth can be expected if the cash flow is utilized to expand into the field of chlorine derivatives for the Pittsburgh market.

ECONOMIC DEVELOPMENT ADMINISTRATION

TECHNICAL
ASSISTANCE
PROJECT

U.S. DEPARTMENT OF COMMERCE

FEASIBILITY STUDY OF CHEMICAL INDUSTRY IN SOUTHWESTERN PENNSYLVANIA

PHASE III

PRIMARY ALUMINUM SMELTER

October 1966

"This technical assistance study was accomplished by professional consultants under contract with the Economic Development Administration. The statements, findings, conclusions, recommendations, and other data in this report are solely those of the contractor and do not necessarily reflect the views of the Economic Development Administration."

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I. REPORT IN BRIEF

A. INTRODUCTION

The proposed 100-acre Reesedale location offers a suitable site for an aluminum reduction plant. In the selection of a site for an aluminum smelter three major cost factors must be considered:

(1) The source of alumina, either captive or purchased that determines the effect of depletion, and the delivered cost of alumina to the smelter.

(2) The electric power rate because 16,000 KWH are needed per ton of aluminum metal manufactured.

(3) The freight charges to move primary ingot from the reduction plant to the fabricator and to the consumer.

The reference design was based upon the installation of two 140-cell potlines, each with a capacity of 40,000 annual tons of aluminum, for a fixed capital expenditure of $78 million. About the same capital expenditure would be required regardless of the site selection--$975 per annual ton of aluminum. The total estimated new investment is $88 million because an additional $10 million would be required for working capital. The return on the investment before tax would be 7.59 per cent. A nominal payout time of 12.9 years was calculated for an independent producer with purchased alumina delivered at $65 per ton and a power rate of 3.9 mills per KWH.

A discounted cash flow analysis showed that an integrated producer will show a better financial return from depletion allowance on captive alumina. Also, an increase in the plant output from 80,000 to 120,000 annual tons of aluminum reduces the unit costs for labor and depreciation. Thus, an integrated producer might take advantage of building the 120,000 tpy plant along with a delivered cost of $55 per ton of alumina. Under these conditions the nominal payout time calculated is 9.25 years for a sales price of 24.5 cents per pound of aluminum.

B. GEOGRAPHICAL ADVANTAGE OF REESEDALE

The Reesedale site has a unique geographical location. It is 60 miles northeast from Pittsburgh on the navigable portion of the Allegheny River. It is close to the heavy concentration of aluminum metal forming and fabricating industries located in the area from Youngstown to Cleveland, Ohio. The proposed Interstate Highway 80 will pass within 25 miles due north of Reesedale so that overnight delivery of pig, billet, ingot or hot metal will be possible to any customer within a trucking distance of 400 miles when the Federal Highway network is completed.

C. POWER RATE

Historically, construction of private power generating units (both hydro and thermal) has been characteristic at most of the aluminum reduction facilities. Coal-fired steam generating units are preferred at present, however, by domestic companies because they offer a low power rate and because they can be built near the heart of the aluminum fabricating and consuming industries, which are within a 250-mile radius of Columbus, Ohio.

From our discussions with West Penn Power Company, a probable power rate of 3.9 mills per KWH has been assumed for a demand in excess of 150,000 kilowatts to manufacture 80,000 annual tons of aluminum. This power rate is either equal to or below that offered by the TVA and by other utilities in Appalachia and the Ohio Valley. It is equivalent to the power rate of a captive-coal-fired power plant with a fuel price of 15 cents per million BTU, which shows an 8.5 per cent return on the investment before tax.

The availability of low cost power in the Pacific Northwest, however, has made this area a formidable contender in attracting new aluminum reduction plants. A power rate of 1.7 to 2.2 mills per KWH justifies an aluminum reduction facility in the Bonneville area despite (1) the long rail haul of alumina from the southeastern section of the

United States, including the Texas Gulf Coast, and (2) the transcontinental shipment of aluminum ingot to fabricators. Also, new sources of low cost alumina originating in Japan, and more recently, Australia and Surinam, have combined with the low Bonneville power rate to permit the Pacific Northwest to maintain a strong competitive position in the aluminum reduction industry. In fact, the projected long-term development of the Columbia River Basin assures that the Bonneville Power Authority can continue to offer a low power rate for many years to come. Recent announcements by some of the aluminum companies show that they are cognizant of this advantage.

For Reesedale to meet the competitive threat of imported alumina to a tidewater reduction facility in the Pacific Northwest, a combined effort must be made on the part of not only the power company, but also the transportation interests. As a result of this combined effort, it is our opinion that some of the fully integrated aluminum companies should be able to establish a new reduction facility at Reesedale to meet the rapidly expanding market for aluminum metal.

Discussions with West Penn Power have indicated that either joint ownership of a steam generating unit or toll conversion of the captive fuel might be negotiated under special circumstances.

D. SOURCE OF ALUMINA

Pennsylvania refractory-grade clays in the vicinity of the Reesedale site might offer an interesting alternative for a long-term source of alumina. In view of the new plant announced recently by the Anaconda Company to recover metal-grade alumina from kaolin-rich Georgia clays, an investigation is recommended of the possible processes for chemical treatment of indigenous clays in central and western Pennsylvania. A modification of the Anaconda process might be feasible to permit combined mining of the massive deposits in the area of both coal for fuel and clays for alumina.

E. MARKET PRICE OF METAL

The financial analysis shows that the current market price of 24.5 cents per pound of aluminum (99.5 per cent purity) requires that the minimum annual capacity of a new smelter be 120,000 tons. An integrated producer has the advantage of captive alumina so that an independent producer will find it difficult to enter the primary aluminum field.

On the basis of the projected growth rate of the aluminum industry, the current market price for ingot appears adequate to generate the funds for expansion.

F. EFFECT OF PRIMARY COST FACTORS

The discounted cash flow method of financial analysis was chosen to evaluate the economic potential of the proposed Reesedale smelter. One advantage of the discounted cash flow method is that it permits calculation of the net present value (NPV) for a given set of operating conditions that can be compared directly with another set of conditions. This calculated NPV is a reliable profit index for a commercial venture.

In general, a discounted cash flow analysis shows the number of years a plant must operate to recover the total capital investment if the annual cash flow is discounted at an assigned rate of interest. The length of the time period selected and the interest rate specified are decisions by corporate management consistent with the financial risks involved within a given industry.

In this study, a discount factor of 11.5 has been applied in all cases to the annual cash flow to allow a nominal rate of return of 6.0 per cent over a 20-year period. In Case A (the reference design) the discounted cash flow is only $82.7 million so that the net present value is a negative $5.3 million - the original investment of $88 million has not been recovered.

Four basic cases were assumed for the reference design to illustrate the contribution of depletion allowance:

Case	Description	NPV[a] $ Millions
A	Output 80,000 annual tons. Sales Price 24.5¢/pound of metal. Purchased alumina at $65/Ton. A power rate of 3.9 mills per KWH. Ingot freight at $10/Ton	(10)
B	Same as Case A, except captive alumina eligible for 15% depletion allowance.	(1)
C	Same as Case A, except manufactured alumina from clay (23% depletion allowance).	(3)
D	Same as Case A, except private power generation from captive coal at 15¢ per million BTU.	(8)

(a) Net Present Value in $ Millions (See Page V-69).

For an integrated producer (Case B) the combined effect of increased plant output and lower delivered cost of captive alumina is illustrated below. It will be noted that Reesedale compares favorably with the Pacific Northwest (Case B_3) for ingot delivered to Philadelphia.

Item	Case B_0	Case B_1	Case B_2	Case B_3
n, Annual output, tpy	80,000	120,000	120,000	120,000
Alumina, $/Ton Del'd.	65	65	55	55
Power Rate, mills/KWH	3.9	3.9	3.9	2.2[a]
Frt. Allow., $/Ton	10	10	10	35
NPV(6/20), $Millions[b]	(1)	18	29	31

(a) Bonneville Power Authority.
(b) Net Present Value of project @ 6% interest for 20 yrs. An ingot price of 24.5 cents per pound was used.

In conclusion, under the present business conditions, an aluminum smelter at the Reesedale site appears more attractive for an integrated organization with both an established market in the northeast quadrant and a captive supply of alumina. For an annual capacity of 120,000 tons of aluminum metal, with 40,000 tons of hot metal, the project will be more attractive. In general, Reesedale, or an equivalent site in southwestern Pennsylvania, will compare favorably with other potential smelter sites in Appalachia, the upper Ohio Valley, and the Pacific Northwest.

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D. L. Stockton

D. L. Stockton

October, 1966

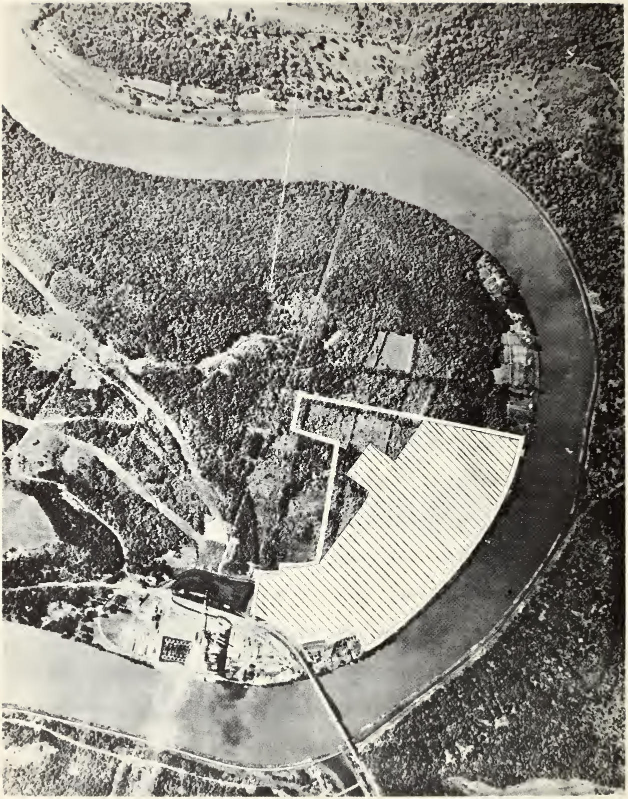
II. PROJECT DESCRIPTION

A. GENERAL

The preliminary reference design for a plant to manufacture 80,000 tons per year of primary aluminum metal has been prepared for the Reesedale site (see Figure A, Page II - 2) in Armstrong County, Pennsylvania. This reference design facility will consist of a carbon plant for the manufacture of pre-baked anodes, two 140-cell potlines for converting alumina to metal, and a casting house to prepare the marketable forms of primary aluminum pigs, sows, billets, and ingot. The plant is also designed so that "hot metal" (molten aluminum) can be shipped directly from the Reesedale site to an aluminum casting operation within a distance of 50 to 400 miles. Suitable insulated containers (crucibles) would be transported by either truck or rail.

A primary aluminum smelter was assumed to require about 1.9 kilowatts of connected power per annual ton of metal capacity. A load factor of 95 to 98 per cent is estimated at 95 per cent power factor. The plant will receive power from the West Penn Power Company 138/132 kilovolt aerial cable power line adjacent to the site. The alternating current power supplied will be rectified to direct current for each pot line. It will then be conducted to the cells, which are connected in series. A direct current of

FIGURE A

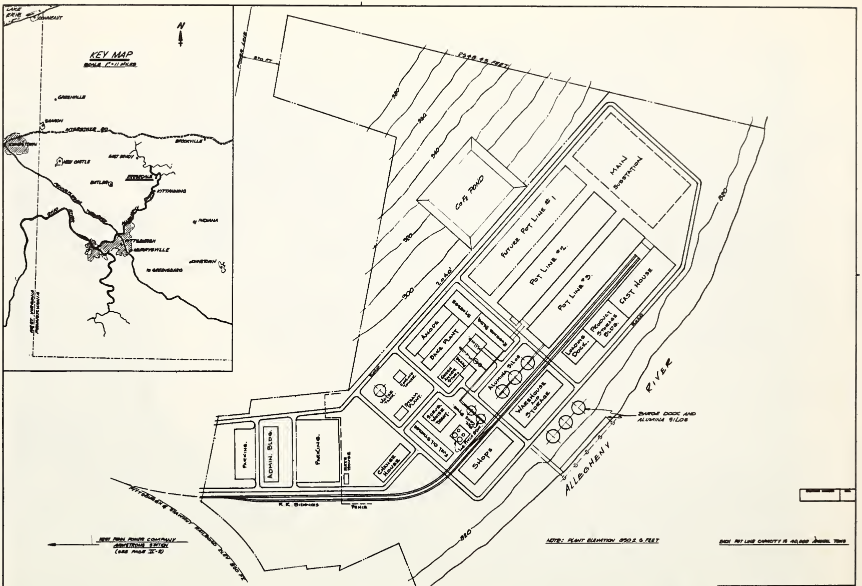


REESEDALE SITE
PRIMARY ALUMINUM SMELTER

120,000 amperes has been assumed. The maximum operating voltage drop across each cell was assumed at five volts.

The basic raw materials will be received by either barge or rail and transferred from the unloading stations to main storage silos. High purity alumina might be hauled from Baltimore or Lake Erie, if a competitive rail freight rate can be established with the proposed barge shipments from Louisiana. Calcined petroleum coke will be received by rail from either West Virginia or Illinois sources. Other miscellaneous materials, such as cryolite, aluminum fluoride, and soda ash will be received in either bulk or bags. Provision must be made for storage of both forms of each raw material. The HSP pitch (high softening point) for the green anode mix will be handled in heated lines and stored in suitably heated and insulated tanks after tank car delivery. The cathode lining will be made up from purchased carbon blocks.

The general layout of the plant (see Figure B, Page II - 4) includes a raw materials storage area, a carbon plant for preparing pre-baked anodes, two potline buildings for the electrolytic reduction of alumina, and a metal finishing area for casting pigs and sows with special direct-chilled casting machines for billets and ingot slabs.



NOTE: PLANT ELEVATION 850 ± 5 FEET

EACH POT LINE CAPACITY IS 40,000 ANNUAL TONS

FIGURE - B
PAGE II-4

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NEW YORK, N. Y.

ALUMINUM SMELTER PLANT
PLOT PLAN.

ARA

PS-006A

Provision has been made to maintain good working conditions in all of the process areas by adequate ventilation. In the carbon plant this will require both general building ventilation and, at some process points, specific ventilation. Carbon dust must be recovered at all transfer points. Exposure to pitch fumes must be avoided during all processing steps.

In the aluminum reduction cell houses (pot line building) special consideration has been given not only to ventilation, but also air pollution. During the charging operation the finely divided alumina and other solids must be collected and recycled. The hazardous and obnoxious gases generated during electrolysis must be vented and scrubbed. The off-gas includes carbon monoxide, hydrogen fluoride and the entrained particles of alumina, carbon, and fluoride salts. Suitable crane-carried and/or mobile units will be designed to permit direct charging of alumina and other solids to the reduction cells. A skirt will be provided at the solids discharge feed point to collect and recycle the fines by dry separation. It will be necessary to scrub the exhaust air from the building to remove both the entrained fines and the gaseous hydrogen fluoride. The scrubber liquor will be neutralized with calcium hydroxide and sent to a settling pond for accumulation of the calcium fluoride precipitate and associated solids. The overflow from the pond will be recycled to the scrubbing units with a bleed to waste so that any build-up of dissolved salts can be controlled. If convenient and economical, recovery of the alumina and fluoride salts can be included at a later date from the stockpiled tails.

B. CAPACITY OF SMELTER

After a preliminary financial analysis had been made of the originally considered 60,000 annual ton plant, combined with a review of the literature, it became evident that the nominal design capacity should be increased from 60,000 to 80,000 annual tons of primary aluminum ingot. This is believed to be the minimum economic capacity for a facility located in an area that is geographically at some disadvantage with respect to freight and power rates. The topographical limitations of the Reesedale site make it imperative to design an especially compact and efficient aluminum smelter in comparison with most of the existing reduction plants.

In order to increase the plant capacity it is proposed to utilize a cell design that will permit a direct current flow of 120,000 amperes. This proposal follows the trend to higher amperage cells, which has characterized design of new aluminum reduction plants during the past ten years, and is being applied to several units now under construction.

To accommodate this increase it has been necessary to make some modification in the cell geometry and improvement in the mechanical and electrical design of the cells. These modifications and changes are sufficiently well understood to give confidence that they will be successfully applied, and are incorporated in the two latest plants constructed in the United States.

The originally proposed reference design at Reesedale was for installation of two potlines with 140 cells each, operating at 90,000 amperes. The use of 120,000 ampere current load, with suitable modifications of cell geometry, will raise this capacity to 80,000 tons per year without materially affecting the physical layout of the cell room. This approach for increased capacity is more economical than that of providing additional cells at the lower amperage, and thereby increasing the total over-all voltage drop across the cell house with consequent higher power rectification costs.

Adequate space has been reserved in the plant layout for a third potline (140 cells) to be added at a future date. This would permit an annual output of 120,000 tons primary metal. Acquisition of the quadrant of property to the west of the present Reesedale site would permit an ultimate expansion of the smelting capacity to 240,000 annual tons. The total installed United States capacity is now 2.721 million annual tons with 0.345 million additional annual tons now under construction. Canada has an annual capacity of 0.898 million tons and 0.145 million tons additional are being planned. Thus, the combined North American capacity is 3.619 million annual tons and will be 4.109 million annual tons within the next three years.

C. ALUMINA SUPPLY

(See Figure C - Diagrammatic Flow Sheet on Page II-9)

A dock (200 feet long x 50 feet wide) will be installed along the river to accommodate barge shipments of alumina (1000-1500 tons). A pneumatic conveying system will transfer the alumina from the barges to silos at the dock for interim storage. A fleet of up to a total of 15 barges can be maneuvered by one 1500-2000 HP river tug boat. Three barges will be unloaded simultaneously and the empty barges moved to a holding area until the entire fleet of 15 has been unloaded and is ready for the return trip. The dock silos will accommodate a total of about 10,000 tons of alumina (about three weeks operating supply).

A suitable rail unloading station for incoming alumina in covered, hopper-bottom cars will be located so

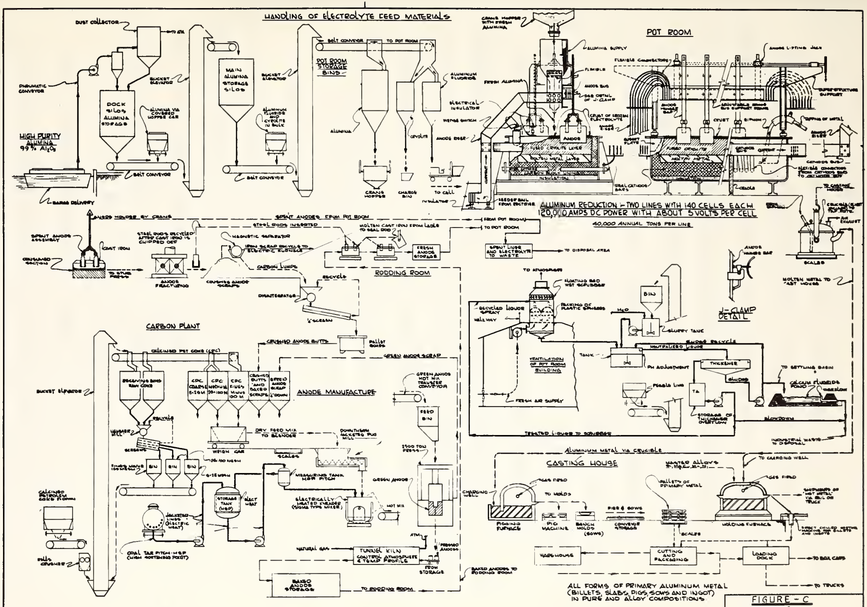

FIGURE - C

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SINGMASTER & BREYER
METALLURGICAL AND CHEMICAL PROCESS ENGINEERS

ALUMINUM SMELTER
REESEDALE SITE

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that the belt conveyor moving material from the dock can also serve for transferring rail shipments of alumina to the main storage area. Cryolite, aluminum fluoride and soda ash will have a bulk unloading station adjacent to the main storage area so that these auxiliary chemicals can be transferred to storage bins inside the potline buildings. A suitable inventory of all chemical reagents in bags will also be stored in the warehouse.

D. CARBON PLANT

The pre-baked anodes for the aluminum reduction cells will be manufactured at the site from calcined petroleum coke, HSP pitch, recycled green anode scrap, and the reclaimed anode butts that are removed from the potlines. The coke will be crushed and ground to a suitable size distribution so that the desired degree of mixing with other components can take place prior to the pressing (molding) operation. In the mix preparation area a weigh car is filled with the desired amount of each of the dry starting materials and is dumped into a sigma-type dough mixer or kneader with the addition of pre-heated liquid HSP pitch to obtain a homogeneous batch of green anode mix.

The green mix is dumped from the open-top sigma mixer and then is elevated to a charge bin above each of two 2500-ton hydraulic presses. The green anode blocks are molded to the required dimensions and density before they are sent to a storage area. The green anode scrap material is recycled to the head of the anode process to be used in preparation of the next green mix batch.

The procedure most commonly used in the past for baking the green anodes employs a gas-fired furnace pit in which the green anodes are supported and surrounded by granular carbon during the baking cycle. The temperature in these furnace pits is controlled as closely as possible by the use of an adjustable gas-fired burner. This operation requires an overhead crane during the loading and unloading cycle. Also, a high recycle load of granular carbon packing material must be removed by pneumatic conveyor prior to unloading the baked and cooled anodes.

In recent years much experimental work has been done in developing techniques by which a tunnel kiln with a regulated atmosphere and a controlled temperature profile can be substituted for the furnace baking pits. This system would obviate the use of granular carbon for support of the anodes during firing and would reduce the unit labor and maintenance cost. The capital expenditure for a continuous system such as the tunnel kiln would be equal to or less than that for the furnace pits. It is considered that any new carbon anode plant should study carefully the advantages of the tunnel kiln system. As yet it has been applied only in a few locations.

It is planned to operate the carbon plant on only a five-day week so that an adequate back-log of fresh anodes must be maintained for operation of the potlines on a seven-day week.

The baked anodes are taken from storage to the final assembly room where the steel anode support rods are inserted and attached to the anode by pouring cast iron between the steel rod and the surrounding carbon wall. A minimum electrical resistance is needed at this steel-carbon interface to carry the massive flow of direct current.

The lower part of the reduction cell lining, which forms the cathode for the electrolysis, may be prepared in the carbon plant if pre-baked cathode blocks are not purchased. A mixture of beehive coke and anthracite coal is mixed with LSP (low softening point) coal tar pitch to fashion a monolithic lining material. This carbonaceous material is then applied as a plastic layer in the steel pot shell and is baked in place. The use of purchased pre-baked carbon blocks has become common with the aluminum manufacturers because the life of a cell lining is increased significantly. As a result, increased cost of the purchased blocks can be justified by reduced annual operating charges.

E. POTLINE REDUCTION UNITS

Two separate buildings(70 feet wide x 900 feet long x 50 feet high) will be used for the assembly of the reduction cells in a total of four lines of 70 cells each. The cells will be arranged in the side-by-side layout although the end-to-end arrangement could be accommodated in the available process area. The construction of the reduction cell will be the standard type in which the structural framework supports a steel liner with nominal over-all dimensions of 25-30 feet long by 12-14 feet wide and 4 feet high. The anode assembly consists of 40 x 600-pound anodes, roughly 30" x 20" x 18", per cell and is arranged so that current can be supplied from an adjustable, overhead anode-bus support frame. Each anode hanger bar can be positioned as desired to establish the optimum anode-cathode distance.

Fresh alumina is usually added to each cell from an overhead charge bin to the longitudinal central area of an enclosed cell. In some cases, a mobile jitney unit is driven along the side of an open end-to-end cell line for charging alumina. The enclosed type of cell will have a removable, sectional hood that permits the fumes and dust created during charging to be exhausted to a central point. A treatment of both dry dust collection and wet scrubbing is given before release to the atmosphere. This is the older technique for pot line ventilation. Alternate ventilation schemes for an "open" cell design are described in Section II-G. These are based on frequent air changes for the entire building with low-pressure-drop,wet scrubbing before release of the off-gas to atmosphere.

The general ventilation in the pot line buildings will consist of a suitable combination of fresh air supply and exhaust to give at least five to ten air changes per hour. During the summer months a high flow of air will be necessary to remove the sensible heat gained from the pot lines and to maintain a dry bulb temperature below 105°F inside the building. During the winter months the flow of air will be reduced by regulating louvred openings in the side of the building.

The bottom of the cell is insulated by alumina placed below the carbon cathode blocks to minimize heat loss from the molten metal-salt layers which are held at 900°C to 1000°C. The two long sides of the pot provide for insertion of the steel cathode rods (about three-inch diameter) which collect the direct current from the carbon cathode layer. The aluminum cathode bus has individual connections to the steel collectors. The cathode bus current is carried to the aluminum anode bus risers of the adjacent cell.

An insulated crucible of 7.5 tons capacity will be used to receive molten aluminum metal syphoned from each cell. A cast-iron dip tube will be lowered into the cell to tap the lower layer of aluminum metal (specific gravity 2.284). About one ton of the metal layer is removed, which is only one inch of the total six to nine inch metal layer depth. Care must be taken to avoid removal of the upper layer of the cryolite electrolyte (specific gravity 2.10) during the tapping operation. Each cell will produce about 1600 to 1800 pounds of metal per 24-hour day at 85 per cent current efficiency so that tapping is done every 28 hours. The filled crucible of three one-ton batches of molten metal will be taken by a jitney-trailer to the casting house after dross is removed and the melt is sampled.

The electrolysis is carried out at a temperature of about 1000°C (anode-electrolyte interface) with the reduction of alumina to aluminum metal. There is a release of oxygen simultaneously which in turn reacts with the carbon anode and forms principally carbon dioxide and some carbon monoxide. The conducting heavier aluminum metal layer on the bottom of the cell supports the upper layer of cryolite-alumina. The vertical temperature gradient is such that the top surface of the bath forms a porous crust of frozen electrolyte and fresh alumina.

As the bath becomes impoverished in alumina, its conductivity and physical characteristics are changed to the point where the resistance increases sharply. This "anode effect", indicated by a sudden rise in the voltage across a cell, is an indication of the need for new alumina addition to the bath. The crust is then broken the entire length of the cell between the anodes and fresh alumina is added. The actual mechanism of the anode effect is complex. It is explained by the inability of the electrolyte to "wet" the carbon anode and, thereby, to conduct current.

F. SPENT ANODE REWORKING

Most of the carbon consumed during electrolysis results from its combination with the oxygen that is released upon reduction of the aluminum oxide. For this reason the anode assembly must be lowered slowly into the molten bath as the carbon anode is reacted. An index point on the anode holder is used to indicate that the spent anode should be removed from the cell and replaced with a fresh anode. The average life of the anodes is about 12 to 14 days. Uniform operation is maintained by following a replacement schedule.

Spent carbon butts are broken from the anode holders in a press and the steel rods are salvaged for reuse. The cast iron ring around the steel rod is recovered by the use of a magnetic separator and the iron is recycled to the rodding room and remelted. The large lumps of anode fragments are crushed to minus 3/4-inch and collected in a suitable bin as reclaimed anode butts. These are returned to the carbon building for reuse, where they serve as a primary source of carbon for a fresh anode dry mix.

When a reduction cell is removed from operation, the electrolyte is removed and is cooled to room temperature for recycling. The old carbon lining is removed by a jack hammer and then is hauled to a suitable tailings disposal area. This carbon cannot be reused because it is contaminated by fluoride salts.

G. VENTILATION REQUIREMENTS

Increased emphasis has been given over the past 10 to 15 years to the design of ventilation systems for aluminum pot lines that will eliminate solids and hydrogen fluoride from the off-gas exhausted to atmosphere.

The conventional system for such cell ventilation consists of individual hoods over each cell, connected to a main exhaust header extending the length of the building. This header leads to a dry dust collector and then a water scrubber before the off-gas is released to the atmosphere. One objection to this arrangement is during the addition of alumina, which involves prior crust breaking, excessive dusting occurs and the dust removal from the operating area is most inefficient. Floor sweepings become a routine duty to recover alumina.

An arrangement of cells developed by the Swiss, which has been installed in various plants in Europe and in the United States, largely overcomes the objections to the conventional cell ventilation scheme described above. The pots are supported on a beam arrangement which permits air flow from the basement area beneath up past the pots to the roof level. The necessity for obstructive hoods over the cells is removed, and accessibility to the cells is much improved. The arrangement has a further advantage in that, when necessary for cell relining, a complete pot may be lowered through the floor, removed on wheeled transport, and replaced immediately by a newly lined pot, thus cutting down materially on the period of time the cell is off the line.

The proposed ventilation scheme is equivalent to that considered necessary to meet all government regulations for air pollution in controlling the amount of fluorine, in all forms, released to the atmosphere (e.g. phosphate fertilizer plants). The pot line building monitors will contain forced-convection, low-pressure-drop, wet scrubbing units for highly efficient general building ventilation and treatment of the off-gas.

It is planned to have each scrubber unit mounted in the monitor to serve about 20 pots. A general air change of 10,000 to 20,000 cubic feet per minute (CFM) per pot will be needed. Total average dust loadings of ten milligrams per cubic foot are estimated along with 10 ppm of sulfur dioxide and 20 ppm hydrogen fluoride equivalent. The wet scrubber liquor will be recirculated at a rate of 500 gpm to each unit. The final off-gas discharged to the atmosphere should contain no more than a total of 50 pounds of "fluorine equivalent" (all forms) over a 24-hour period. This will require monitoring of the off-gas streams both before and after entering the scrubber unit. The collected fines will be carried as a thin slurry in the liquor discharged from each scrubber unit and will flow to an outside mixing tank for addition of lime and adjustment of pH before entering a thickener for settling. The mud discharged from the thickener will be recycled to the neutralization tank and a sidestream will be withdrawn to the calcium fluoride pond area.

The lime is supplied from a silo that is filled with pebble lime elevated from a rail car. The lime is slurried with water before it is sent to the neutralization tank at a controlled rate. The calcium fluoride sludge, plus the miscellaneous aluminum and other fluoride salts that are carried down during the precipitation step, are allowed to settle in a pond. The pond overflow liquor is discharged to the main liquid waste stream from the plant. This liquor will be monitored for total solids, dissolved fluorides, and pH by a suitable sampling and recording instrument over a 24-hour basis.

The water overflow from the thickener is sent to a storage tank where its pH can be adjusted, if necessary, with sodium carbonate before it is returned to the scrubber circuit inside the pot line buildings. It is necessary to withdraw a portion of this thickener overflow to waste periodically in order to avoid a build-up of soluble salts after an extended number of recycles.

The recycle liquor blow-down stream is also monitored for record purposes so that there will not be any obnoxious and undesirable materials discharged into the river. Occasionally samples will be taken and checked for both biological oxygen demand (BOD) and chemical oxygen demand (COD) Also, biological surveys, both upstream and downstream of the plant, will be conducted annually, at least, to show that the waste liquor discharged to the river has not disturbed the marine life.

No effort will be made to recover any of the contained alumina or fluoride compounds from the sludge material collected in the waste pond. It will be necessary to allow the sludge to dry by solar evaporation and to haul the sludge away periodically to an approved area for dumping. Many of the foreign plants rework this material because it represents about one to two per cent of the raw materials fed to the plant. It is felt, however, that the design of an efficient charging system for the potlines will reduce the entrainment loss of alumina and the other solids added to the point so that waste treatment will not be necessary.

H. CASTING HOUSE

The crucible containing molten aluminum metal withdrawn from the potline cells will be transported to the casting house where the net weight of metal will be determined. The ladle will then be emptied into a charging well that feeds either a pigging furnace or a holding furnace. It is necessary to provide for reheat of the mobile crucibles at the casting house in the event that a long holding period occurs before the metal is poured.

A 20-ton gas-fired pigging furnace will service both a pigging machine for making 50-pound pigs and bench molds for making 500-pound sows. The molten material will be withdrawn from a hearth of the pigging furnace into a small bench mold pouring ladle operated by a pendant control. Cast shapes will be discharged onto a roller conveyor feeding to a central scale for final weighing, stacking, strapping and removal to the storage area on pallets.

A holding furnace will be used to prepare special custom aluminum alloys, by master alloy addition, as well as to provide a transfer for hot metal shipment by either truck or rail car in suitable insulated containers. In addition, it will allow special alloy materials to be prepared for direct-chilled casting in the form of billets and ingot shapes. The necessary accessories for handling the aluminum shapes through the various steps of the casting house operation that include cutting, wrapping, strapping, packaging, and transferring to the storage area will be included in the design. Overhead cranes will service the building.

Ingots of the primary aluminum metal and all of the other finished shapes, as well as process materials, will be carefully sampled and recorded for reference. Transport of samples to the laboratory will be speeded by the use of a pneumatic rabbit (tube conveyor) system to the assay area. A teletype, or equivalent, machine will be used to return the analytical results from the laboratory to the casting house office to avoid any delay.

A railroad loading platform will be provided inside the building for rail shipments of finished materials. A covered truck dock will also be provided near the main storage area.

I. CHEMICAL LABORATORY

1. Process Control - Sampling techniques will be established to obtain representative samples of all incoming raw materials. Sample preparation by blending and splitting must be done for raw alumina and all raw materials received in bulk, as well as for all in-process control samples.

Special provision has been made to handle process control samples for the carbon plant. A suitable laboratory adjacent to the operating area (e.g. control room or foreman's office) is planned. Size reduction, screening, and chemical analyses are needed to manufacture reliable anodes. A radiation source will be used to serve as a means of measuring the density in the pressed and baked anodes.

2. Quality Control - A complete metallography laboratory will be needed to determine the characteristics of the mill products before release for shipment. The use of the most sophisticated techniques for determing metallic and non-metallic impurities in the metal is imperative in order to compete. Many of these impurities can be determined from X-ray fluorescense, which is rapid if a suitable background matrix can be calibrated, or by emission spectrography. Some of the impurities must be measured by use of vacuum-melting furnaces to release dissolved gases, such

as hydrogen, oxygen, and nitrogen, that are critical in casting operations. Occasionally, it will be necessary to employ neutron activation analysis to determine a trace impurity.

3. Special Instruments - The following special instruments should be provided for routine control work:

a. Emission Spectrograph. One of the most expensive analytical devices, but considered to be the most essential for both process and quality control. A highly trained crew of three must be provided to operate each machine with carefully prepared samples.

b. X-ray Fluorescence. These units are indispensable for both process control and product samples of aluminum. At least three to four machines will be needed because it is recognized that they are invaluable in smelter operations where variance in the chemical raw materials fluctuates hourly. The reduction to a minimum period of lag time between taking a sample and reporting the assay is important in maintaining optimum plant conditions. If necessary, X-ray fluorescence units can be installed in the process line for continuous recording of chemical compositions. Thus, certain specific metallic impurities, such as iron or sodium, can be checked continuously in the final metal withdrawn from a casting furnace.

c. Thermal Gravimetric Analysis. These units have been developed to reveal critical chemical and physical data for a wide variety of solid samples. Differential thermal analysis has been combined with a gravimetric record of the material that is a reliable method to analyze petroleum coke, green anode mix, alumina, and other chemical raw materials.

d. Electron Microscope. As a machine needed to check raw materials, in-process samples, and primary metal products, the electron microscope finds invaluable application. One reason for including it in this Reesedale proposed smelter is that its use will enable the plant operating group and the on-site development crew to follow the performance of both the carbon anodes and carbon block cathode lining over an extended period.

e. Metallography. A complete set of physical testing equipment will be needed for the aluminum ingot and alloyed aluminum products. This would include two Instron testing machines, one for service at elevated temperatures. All of the usual accessories for preparing and examining metallographic samples will be included in a complete microscopy laboratory.

f. Chemical Analysis. Complete wet chemical facilities will be provided for process control, quality control and development group analytical support. Infra-red, ultraviolet, and reflectance machines will be selected as needed for occasional or routine use. Specific surface measurement by nitrogen or argon adsorption might be needed for the carbon plant. Analytical balances, titration apparatus, and particle size determination methods will be included in the chemical laboratory equipment.

III. CAPITAL COST

A. DESIGN CAPACITY - 80,000 ANNUAL TONS

SITE PREPARATION	Capital Cost, Millions
Clearing and Grubbing	$0.500
Excavation and Grading	4.000
Sub-Total	4.500
SITE DEVELOPMENT	
Roadways and Sidewalks	0.400
Parking Lots	0.300
Railroad Sidings	0.600
Scales for Trucks and Boxcars	0.200
Fencing	0.200
Alumina and Metal Barge Docks	1.300
Sub-Total	3.000
UTILITY SYSTEMS	
Storm Sewer and Drainage	0.500
Sanitary Sewer and Treatment	0.300
Firewater Storage and Distribution	1.200
Process Water	0.500
Chilled Water for Air Conditioning	0.250
Cooling Water	0.500
Water Treatment (River Intake)	0.500
Natural Gas Distribution	0.250
Low Pressure Steam	0.350
Plant Air	0.100
Instrument Air Supply	0.100
Fuel Oil Storage	0.075
Main Electrical Substation (Switching)	0.500
Electrical Power Distribution	0.750
Yard Lighting	0.125
Sub-Total	6.000

	Capital Cost, Millions
SITE FACILITIES	
Security, Dispensary and Garage	$0.250
Administration and Cafeteria	1.500
Change House and Lunch Room	0.400
Laboratory and Furniture	1.250
Warehouse	0.900
Shop and Equipment	1.100
Utilities Building Complete	1.100
Sub-Total	6.500
CARBON PLANT	
Materials Receiving and Storage	0.500
Carbon Mixing and Pressing	2.000
Tunnel Kiln for Baking Anodes	3.000
Rodding Room, Office and Laboratory	1.500
Spent Anode Reworking	1.000
Sub-Total	8.000
ALUMINA RECEIVING	
Dock Unloading and Storage	1.500
Main Storage Silos	1.500
Sub-Total	3.000
REDUCTION LINES	
Feed Tanks with Supply and Distribution	1.500
280 Cells (Complete)	12.500
Electrical Rectification	5.000
Dust and Fume Control	2.500
Sub-Total	21.500

	Capital Cost, Millions
CAST HOUSE	
4 x 25-Ton Pigging Furnaces	$0.600
4 x 25-Ton Holding Furnaces	0.600
2 x 100 TPD Pigging Machines	0.400
2 x 50 TPD Bench Molds	0.400
2 x 100 TPD Continuous Casting Machines	1.250
Building (200' x 600' x 50')	1.500
Cutting and Sawing Machines	0.125
Packaging and Shipping	0.125
Sub-Total	5.000
MISCELLANEOUS EQUIPMENT	
Office Equipment	0.500
Laboratory Apparatus	1.500
Spare Parts - Mechanical	1.000
Mobile Equipment and Cranes	0.500
Sub-Total	3.500
TOTAL PLANT COST	$61.000
Engineering, Etc. - 12%	7.320
Contractor's Fee - 4%	2.440
ESTIMATED TOTAL COST	$70.760
Contingencies - 10%	7.076
TOTAL FIXED INVESTMENT	$77.836

UNIT FIXED INVESTMENT . . . . $975 Per Ton of Metal

B. DESIGN CAPACITY - 120,000 ANNUAL TONS

(Additional costs over those given in Section III - A)

	Capital Cost, Millions
UTILITY SYSTEMS	$ 2.750
CARBON PLANT	2.000
ALUMINA STORAGE	0.500
REDUCTION LINES	11.250
CAST HOUSE	2.500
INCREMENTAL PLANT COST	$ 19.000
Engineering - 12%	2.280
Contractor's Fee - 4%	0.760
INCREMENTAL TOTAL COST	$ 22.040
Contingencies - 10%	2.204
INCREMENTAL FIXED INVESTMENT	$ 24.244
ORIGINAL FIXED INVESTMENT	77.836
TOTAL FIXED INVESTMENT FOR 120,000 ANNUAL TONS	$102.080

UNIT FIXED INVESTMENT . . . . $850 Per Ton of Metal

INCREMENTAL UNIT INVESTMENT
FOR ADDITIONAL POTLINE . . . $603 Per Ton of Metal

C. DESIGN CAPACITY - 240,000 ANNUAL TONS

(Additional costs over those given in Section III - B)	Capital Cost, Millions
SITE PREPARATION	$ 6.000
SITE DEVELOPMENT	3.000
UTILITIES	4.250
SITE FACILITIES	3.000
CARBON PLANT	4.000
ALUMINA	1.500
REDUCTION LINES	32.750
CAST HOUSE	5.000
MISCELLANEOUS EQUIPMENT	2.500
ADDITIONAL PLANT COST	$62.000
Engineering - 12%	7.440
Contractor's Fee - 4%	2.480
ESTIMATED ADDITIONAL TOTAL	$71.920
Contingencies - 10%	7.190
ADDITIONAL FIXED INVESTMENT (For Second 120,000 Annual Tons)	$79.110
INITIAL FIXED INVESTMENT (For First 120,000 Annual Tons)	$102.080
TOTAL FIXED INVESTMENT FOR 240,000 ANNUAL TONS	$181.190

UNIT FIXED INVESTMENT . . . . $755 Per Ton of Metal

D. POWER PLANT UNIT

A mine-mouth, coal-fired steam generating station will have a fixed investment of $100 to $125 per kilowatt nameplate capacity for a 400 to 1000 megawatt unit. The estimated electrical power supply will be about 200 megawatts for the 80,000 annual ton primary metal facility. The nominal operating time (plant factor) is assumed at 80 per cent for this operation and a nominal connected power source of two kilowatts per annual ton of metal.

Thus, the additional capital investment for a captive or co-owned power generating unit is estimated at about $22 million. This power unit will be depreciated over the life of the project - assumed at 20 years, or five per cent annually on a straight line basis.

No capital has been assumed for a contractor to mine a coal deposit that will be leased or purchased by the power plant operating group.

E. ALUMINA REFINERY

A literature survey combined with announcements of new mining, refining, and shipping facilities for the conventional bauxite ore deposits and its conversion to pure (metallurgical grade) alumina shows a total fixed investment of $250 per annual ton of alumina. This is $500 per annual ton of metal for the basic raw material, pure alumina.

Alternate sources of 1000 tons per day of pure alumina, especially those based on a chemical treatment of domestic clays, have been estimated by the Bureau of Mines. A list of the methods with the pertinent data from the engineering studies at the Metallurgy Research Center (College Park, Maryland) of the Bureau of Mines is:

Method	Unit Capital Cost Per Annual Ton	Unit Manufacturing Cost, Per Ton of Alumina
1. ALUM SALTS		
a. Potassium Alum Process	$155	$ 96.15
b. Ammonium Sulfate (Est'd)	(200)	(87.50)
2. SULFURIC ACID LEACH		
a. Electrolytic Iron	$117	$ 81.35
b. Chemical	99	82.08
c. Ethanol Precipitation	94	86.17
3. HYDROCHLORIC ACID LEACH		
a. Isopropyl Ether SX	$229	$ 65.09
b. HCl Gas Precipitation	289	89.04
c. Gas Precipitation plus SX	357	119.65
d. Modified Bayer (Caustic Leach)	266	73.79
e. Lime-Soda Sinter Purification	279	80.47
4. CONVENTIONAL BAUXITE (See Estimate in Section V-C).	$250	$ 65.00

A plant to manufacture 160,000 annual tons of alumina from imported bauxite would require a capital expenditure of $30 million for the refinery only, which is $200 per annual ton of product. The investment for the mining, haulage, and transportation of bauxite would be equivalent to $50 per ton pure alumina, or $25 per ton raw bauxite ore.

F. SUMMARY OF CAPITAL EXPENDITURES

	Millions of Dollars			
Ingot Capacity Annual Tons	Reduction Plant	Alumina Plant(a)	Power Plant	Total
40,000	60	20	15	95
80,000	78	30 (b)	22	130
120,000	102	50	33	185
240,000	181	84	60	325

(a) Based on conversion of bauxite ore.

(b) A cost of $35 million is estimated for an alunina refinery for extraction of certain domestic clays.

IV. OPERATING COST ESTIMATE

A. DESCRIPTION OF PLANT ORGANIZATION

1. Introduction

A total work force of 430 people will be required to produce 80,000 tons of primary aluminum metal annually. This is 186 annual tons per production employee, which is significantly above the overall national average of 150 annual tons per production worker in 1963. The average annual payroll per employee for the Reesedale Smelter would be $7500 in comparison with the national average of $7300 for the year 1962.

A highly competent group of administrative and technical personnel has been outlined because emphasis will be placed upon adequate planning to meet production schedules and quality control of, not only the primary metal, but also special alloys. Cost control and cost reduction programs require technical coordination of all activities to maintain the highest standards of quality and lowest operating cost in order to establish a competitive position. Recruiting of all personnel would be selective to hire highly skilled operators and mechanics, who had adequate background and experience to qualify for a suitable training program.

One example of the specialized qualifications is for the analytical control laboratory chemists and assistants. The technicians must have the equivalent of two years of college training because the work requires considerable knowledge of chemistry. The emission spectrograph, gravimetric analysis, and x-ray fluorescence machines are rapid and accurate but demand a reliable standard be established and confirmation by the standard (wet method) analytical techniques. Thus, the chemical laboratory will be developing new methods and standards while conducting its routine services for the operating and shipping groups.

Another example is the caliber of the research and development team that has been included for this smelter. It is felt that liaison between the plant development group and the central corporate research organization, or scientific centers in the northeast quadrant, will permit a dominant marketing position to be maintained.

This is being done by the aluminum industry from articles that have appeared in the literature on the life of the cell components, increase in the size and output of a cell, and the manufacturing techniques for the carbon anodes.

2. Annual Estimated Payroll

The minimum plant staff to operate, maintain, and supervise this plant will require 430 people. A breakdown by the different functions is given below with details on pages IV-4 thru IV-7:

CLASSIFICATION	WORKERS	ANNUAL PAYROLL
Operating Crews		
Carbon Plant	45	$ 288,000
Reduction Lines (2)	80	536,000
Casting House	64	428,000
Sub-Total	189	1,252,000
Administration	9	140,800
Industrial Relations	25	143,800
Analytical Laboratory	25	196,000
Development Laboratory	15	168,000
Office	35	249,000
Operating Supervision	35	339,600
Maintenance Supervision	13	135,600
Maintenance Crew	44	355,200
Bull Gang	40	216,000
PLANT STAFF	430	$3,196,000

OPERATING CREWS:

CARBON PLANT	ANNUAL RATE	ANNUAL PAYROLL
3x1 - Coke Grinding	$ 6,000	$ 18,000
3x2 - Green Mix	6,000	36,000
3x2 - Pressing	8,000	48,000
3x2 - Baking	8,000	48,000
3x2 - Rodding	6,000	36,000
3x2 - Fracturing	6,000	36,000
3x2 - Butt Crushing	6,000	36,000
3x2 - Helpers	5,000	30,000
3x15 per shift of 45 total		288,000
REDUCTION LINES		
4x2 - Alumina Bins	6,000	48,000
4x2 - Crane Operators	10,000	80,000
4x2 - Jitney Drivers	7,000	56,000
4x2 - Pot Line Group Leaders	8,000	64,000
4x8 - Pot Workers	6,000	192,000
4x2 - Crucible Fillers	7,000	56,000
4x2 - Helpers	5,000	40,000
4x20 per shift or 80 total		536,000
CASTING HOUSE		
4x2 - Scale Men	6,000	48,000
4x2 - Pigging Furnace	8,000	64,000
4x2 - Casting Machine	8,000	64,000
4x4 - Helpers	6,000	96,000
4x2 - Packaging	6,000	48,000
4x2 - Jitney Drivers	6,000	48,000
4x1 - Crane Operator	8,000	32,000
4x1 - Loaders	7,000	28,000
4x16 per shift or 64 total		428,000
TOTAL - 189 Hourly Operators		$1,252,000

ADMINISTRATION	ANNUAL RATE	ANNUAL PAYROLL
1 - Plant Manager	$25,000	$ 25,000
1 - Secretary @ $600/mo.	7,200	7,200
1 - Plant Superintendent	22,000	22,000
1 - Secretary @ $550/mo.	6,600	6,600
1 - Technical Superintendent	20,000	20,000
3 - Department Heads	18,000	54,000
1 - Secretary @ $500/mo.	6,000	6,000
9		140,800
INDUSTRIAL RELATIONS		
1 - Personnel Manager	15,000	15,000
1 - Guard Captain	10,000	10,000
8 - Guards	5,000	40,000
1 - Fire Chief	10,000	10,000
3 - Safety Inspectors	6,000	18,000
1 - Doctor (on retainer)	6,000	6,000
1 - Nurse	7,200	7,200
7 - Janitors	4,000	28,000
1 - Receptionist	4,800	4,800
1 - PBX Operator	4,800	4,800
25		143,800
ANALYTICAL LABORATORY		
1- Chief Chemist	16,000	16,000
4- Analysts @ $1000	12,000	40,000
8- Technicians @ $700	8,400	67,200
12- Samplers @ $450	5,400	64,800
25		196,000
DEVELOPMENT LABORATORY		
3 - Research Chemists	15,000	45,000
3 - Process Engineers	15,000	45,000
6 - Senior Technicians	10,000	60,000
3 - Junior Technicians	6,000	18,000
15		$168,000

OFFICE	ANNUAL RATE	ANNUAL PAYROLL
1 - Office Manager	$18,000	$ 18,000
1 - Secretary @ $500	6,000	6,000
1 - Plant Accountant @ $1200	14,400	14,400
3 - Bookkeepers @ $750	9,000	27,000
3 - Accounting Clerks @ $500	6,000	18,000
2 - Typists @ $400	4,800	9,600
2 - Mail Clerks @ $400	4,800	9,600
1 - Purchasing Agent	15,000	15,000
3 - Buyers @ $750	9,000	27,000
3 - Clerks @ $500	6,000	18,000
3 - Typists @ $400	4,800	14,400
1 - Warehouse Supervisor	12,000	12,000
3 - Office Clerks	6,000	18,000
5 - Stock Clerks	4,800	24,000
3 - Cost Control Clerks	6,000	18,000
35		249,000

OPERATING SUPERVISION		
1 - Mill Superintendent	18,000	18,000
4 - Mill Foremen	12,000	48,000
1 - Yard Foreman	9,600	9,600
3 - Yard Group Leaders	7,200	21,600
8 - Carbon Plant Shift Foremen	9,600	76,800
8 - Reduction Plant Shift Foremen	9,600	76,800
8 - Casting House Shift Foremen	9,600	76,800
2 - Clerks	6,000	12,000
35		$339,600

MAINTENANCE SUPERVISION	ANNUAL RATE	ANNUAL PAYROLL
1 - Plant Engineer	$18,000	$ 18,000
4 - Mechanical Foremen	10,000	40,000
1 - Electrical Engineer	16,000	16,000
1 - Instrument Engineer	16,000	16,000
1 - Shop Foreman	12,000	12,000
1 - Machinist	9,600	9,600
1 - Tool Room Clerk	6,000	6,000
3 - Office Clerks	6,000	18,000
13		135,600
MAINTENANCE CREW		
20 - Mechanics	8,400	168,000
6 - Electricians	8,400	50,400
4 - Carpenters	7,200	28,800
6 - Instrument Men	8,400	50,400
8 - Shift Mechanics	7,200	57,600
44 Total Mechanics		355,200
BULL GANG		
8 - Truck Drivers	6,000	48,000
12 - Yard Men	5,000	60,000
8 - Mechanical Helpers	6,000	48,000
12 - Operator Helpers	5,000	60,000
40		216,000

PLANT STAFF - 430 with an annual payroll - $3,196,000

B. BASIC RAW MATERIALS

1. Alumina

A high purity aluminum oxide with 99.0 percent minimum alumina (Al_2O_3) is prepared from high-grade bauxitic ores (55-65 percent alumina) by the Bayer refining process. These alumina refinery operations have been carried out usually at a domestic deep-water port or equivalent site. During the last few years, however, construction of the refinery at the foreign shipping port for bauxite ore has been evident to reduce the transportation charges. A ratio of about 4:1 for the weight of bauxite ore per unit of aluminum metal can be used in estimating the requirement of bauxite ore.

Thus, for an aluminum refinery with a design capacity of 80,000 tons per year, the amount of ocean cargo handled annually would be 160,000 tons of pure alumina or 320,000 tons of bauxite ore. At an estimated ocean haulage cost of $5-10 per ton of both materials, this represents an annual savings of 0.800-1.600 million dollars. Since this is a savings of $10-20 per ton of primary metal, it is significant because it represents a cost reduction of 0.5-1.0 cent per pound of metal.

Concentration of the domestic alumina refineries along the Gulf Coast allows ocean-going ore vessels to deliver bauxite throughout the year, provides low-cost process steam and electrical power from abundant natural gas fuel, and permits a plentiful supply of caustic soda for the Bayer process. In addition, excellent transportation rates have been established to move the pure alumina to the aluminum smelters via rail, river barge, or ocean carrier.

Smelters have been located where the power rate has been, essentially, the primary cost element following the cost of alumina. With an increase in the freight rates on metal ingot, however, it became necessary to locate the smelters closer to the fabricator and consumer. Coupled with this marketing development has been the availability of electrical power since 1955 in the bituminous coal regions of Appalachia and the Ohio River Valley at a rate equal to, or below that of hydro projects, except the Pacific Northwest (Bonneville Power Authority).

As a result, new facilities for the electrolytic reduction of alumina have been built closer to the weighted geographical center of aluminum consumption, near Columbus, Ohio. The end use of the primary aluminum metal is controlling because freight and inventory charges for the ingot and the fabricated item must be held to a minimum. Thus, new plants for the manufacture of primary aluminum have been built in the lower and middle Ohio Valley to optimize the cost elements of alumina haulage, power rate, and ingot freight. The transportation of liquid aluminum (called "hot metal") up to a distance of 300 miles is being done to eliminate the ingot casting step at the smelter and the remelting operation at the foundry or extruded metal fabrication site.

Specifications for the pure alumina are:

a) Chemical Analysis

		Typical
Al_2O_3	(99.0% Min.)	99.5%
SiO_2	(0.50% Max.)	.01 - .025%
CaO		.00 - .005
Na_2O	(0.75% Max.)	.20 - .40
Fe_2O_3	(0.050%Max.)	.02 - .035
TiO_2	(0.015%Max.)	.001 - .005
L.O.I.	(1.50% Max.)	.25 - .80

b) Physical Properties

Free Flowing Powder	
Bulk Density	55 lbs./cu.ft.
Screen Size:	
Minus 200-Mesh (74 microns)	30%-50%
325-Mesh (37 microns)	10%-25%
Angle of Repose	37°

c) Methods of Shipping

It is moved only in bags or in closed container (barge, or covered hopper-bottom rail car), to maintain purity and prevent exposure to moisture.

d) Delivered Price

Pure alumina can be purchased at domestic alumina plants along the Gulf Coast or at eastern ports for $60-65 per ton. It must move in protected equipment so that imported material requires immediate transfer from the ship to a covered rail car over a 24-hour period. Since 10,000 to 30,000 tons of alumina is carried by a vessel, a fleet of about 50-100 covered rail cars, each of 100-ton capacity, is needed to permit a minimum turn-around time for the ship. Such equipment is not always available on a monthly schedule in order to keep the aluminum plant supplied with alumina.

An alternate plan would be construction of suitable silos at the port of entry for at least 50,000 tons of alumina. Then a fleet of only 15x100-ton covered rail cars would be needed to move an average of 300 tons alumina per day. Three cars each loading, inbound supply, unloading, outbound return, and spare would be in service. At an estimated purchase price of $20,000 per car, an investment of $0.300 million would be required. At least $1.700 million would also be needed for building the dock silos. The interest and sinking fund charges on a total investment of $2.000 million must be carried in addition to the out-of-pocket freight charge of about $4-5 per ton, according to the railroad representative contacted, for the Baltimore to Reesedale routing. Thus, the freight and amortization charges would be $5-6 per ton of alumina.

Under the present circumstances, it is obvious that imported alumina via an eastern port of entry, followed by a railroad haul of 300 miles to Reesedale, cannot compete with the 1200-mile barge haul from the Gulf area. As a result, the new aluminum smelters in the Ohio Valley are supplied with pure alumina by barge exclusively. Nevertheless, it is believed that a competitive situation could be developed by local or state financial assistance to build alumina silos at the port and to purchase the 15x100-ton rail cars, or equivalent rail-truck equipment. It is believed that the rail freight rate could be negotiated to compete with the barge haul charges. This arrangement becomes more attractive as the amount of alumina is increased above the 160,000 annual tons needed for the proposed first two lines of the Reesedale Smelter. Some of the upper Ohio Valley aluminum reduction plants might use the Port of Baltimore, plus a rail haul for captive or custom foreign sources of alumina.

It must be emphasized that during the last 25 years, the major market for fabricated aluminum has been along the Gulf Coast (Florida and Texas) and the Pacific

Coast. The applications of aluminum, however, in the transportation, container and packaging, and structural materials areas have brought some of the new reduction plants closer to or inside the northeast quadrant of the United States. The smelters have been moved closer to the casting, extrusion, rolling and other fabrication plants adjacent to the population centers.

e) Unit Usage of Alumina

The electrolytic reduction of aluminum oxide dissolved in the fused cryolite layer at 950°-1000° centrigrade can be assumed to follow this reaction:

(1) Dissolution of Alumina

Al_2O_3 + fused cryolite = $2Al^{+3} + 3\ O^{-2}$ ions

The eutectic composition (15.5% Al_2O_3) has a melting point of 935°C.

Pure cryolite melts at 995°C and pure alumina at 2050°C. At 1000°C, over 20 percent alumina can be dissolved in fused cryolite but the electrolysis is carried out in the range of 5-15 percent alumina.

(2) Cathode Reaction

$2Al^{+3}$ ions + 6 electrons = $2Al^{\circ}$(metal)

Thus, the theoretical requirement of

pure alumina is 1.89 pounds per pound of metallic aluminum. An actual unit usage factor for commercial operation of 1.92 is assumed for the manufacturing cost estimate. This represents an overall physical loss of about one-half of one percent during unloading, conveying, charging, which agrees with a normal dust loss for handling minus 200-mesh material. An efficient dust collection system will permit recovery of most of the alumina in the dry state by cyclones or bag filter arrangements. Another average one percent loss is based on the 99.0 percent purity of the alumina delivered to the plant.

f) Unit Cost

This is the product of the basic material factor (unit usage) and the delivered price of pure alumina. Information supplied by the producers and transportation industries indicates that alumina can be delivered to Reesedale from the Gulf Coast via barge for $65-70 per ton. Imported material from Baltimore will be about the same price, or higher, because adequate facilities for unloading do not exist and the quoted rail freight is higher than the barge freight.

The unit cost of alumina then is about $130 to $150 per ton of primary metal, or 6.5-7.5 cents per pound of ingot. Thus, pure alumina accounts for about 35 ± 2.5 percent of the total unit cost of primary aluminum. Since it is the major cost element, extensive development of foreign bauxite deposits has been necessary to guarantee a future supply.

The conversion of imported bauxite ore at Reesedale was one alternate considered to add more industrial operations to the Kittanning area. Under the best conditions, the delivered price of crude bauxite ore would be at least $15-20 per ton at Reesedale. About four tons of bauxite per ton of metal would be required, so that the unit cost of the raw ore at Reesedale would be $60-80 per ton, exclusive of any materials and processing charges during conversion to pure alumina.

Again, the inability to haul economically imported crude bauxite beyond the receiving port validates the need to convert the raw bauxite ore as close as possible to the mine site, so that the overall transportation charges per unit of metal are held to a minimum.

2. Petroleum Coke

In the proposed plant only calcined petroleum coke will be consumed by the carbon electrode department.

Green petroleum coke is used by many of the existing smelters to serve as a filler during the anode baking cycle, which is then recycled as calcined material to prepare a suitable anode paste. By changing from the "pit furnaces" for baking green anodes to a continuous tunnel kiln, the green petroleum coke has been deleted from the incoming raw materials. If a carbon packing material is needed during the green anode baking cycle in the tunnel kiln calcined petroleum coke (CPC) will suffice and, in addition, simplify the operations in the electrode plant.

Use of carbon electrodes has been characteristic of the original Hall reduction process. Recently, merchant cathode blocks have been made available at a competitive price. It is necessary, however, to continue the manufacture of carbon anode blocks on a captive basis.

a. Chemical Composition

It is necessary to purchase only the purest form of carbon for electrodes in the pot lines, so petroleum coke from crude oils was selected. This is the normal source of carbon for the manufacture of carbon and/or graphite products (e.g. electrodes). The green petroleum coke has only 0.25 percent ash content and less than 2.0 percent sulfur. The calcined petroleum coke has the following composition:

Ash	0.5 percent maximum
Sulfur	1.0 - 1.1 percent
Iron (Fe)	.02 - .04 percent
Silicon (Si)	.02 - .04 percent
Real Density	2.04 minimum
Volatile	1.00 percent maximum

An alternate to the calcined petroleum coke, which is available from the Great Lakes, Gulf Coast, and other oil refining areas, is calcined gilsonite from Grand Junction, Colorado. Better performance with this type of carbon has been reported but the capacity of the Colorado plant is limited and the delivered price is higher than that from petroleum refinery sources.

In the Pacific Northwest, calcined petroleum coke is available from both Los Angeles and San Francisco at a delivered price below that for either midwestern coke or Colorado gilsonite.

b. Physical Handling

The material will be shipped in 50-ton, hopper-bottom cars, covered if available, as 2-inch lump or egg size material. The bulk density is about 50 pounds per cubic foot so that a storage volume of 200,000 cubic feet is estimated for a 60-day supply of 5000 tons. Fifty rail cars per month will be inbound.

c. Delivered Price of Coke

A quoted price range of $35-40 per ton was derived by contacting the suppliers in the Great Lakes area for calcined petroleum coke. The shortest haul is from Cresap, West Virginia, so that a delivered price of $35 per ton has been used in the cost estimate.

Green petroleum coke can be obtained for a delivered price of about $25 per ton. Allowing for a weight loss of 15-20 percent during drying and calcination, however, in addition to the added processing charges, shows that, at best, captive calcination would only "break-even" on a cost comparison with purchased calcined petroleum coke.

d. Unit Cost

Since the carbon anodes are consummable in this reduction because oxygen is released, the manufacture of carbon anodes is a significant cost element. Only about two-thirds of each anode is reacted in the cell so that a materials handling operation must be carried out to rework the resulting anode butts. In general, the anodes must be manufactured at the point of consumption to save packaging and freight charges and to transfer the anodes from a plant inventory, exclusive of any sales charges and profit.

The theoretical usage of carbon anodes can be estimated by the assumed combination with nascent oxygen released at the anode:

$$3O^{-2} \text{ ions} - 6 \text{ electrons} = 3\ (O)^{\circ} \text{ atoms}$$

$$\frac{3}{2}C + 3(O) = \frac{3}{2}\ CO_2,$$

Then 0.375 pounds of carbon per pound of oxygen is needed to form carbon dioxide. Since 0.89 pounds of oxygen is released per pound of aluminum, this calculates to 0.333 pounds carbon (as carbon dioxide) per pound of metal. Some carbon monoxide is formed by secondary reaction.

The overall average consumption of calcined petroleum coke is 0.50 pound of metal. The unit cost of coke is then estimated at $17.50 per ton of metal ingot.

3. Coal Tar Pitch

As a binder for the carbon particles in the green anode mix, high softening point (HSP) pitch (250°F) is needed. The pitch is maintained at a temperature of 400° to 450° F. to increase its fluidity during pumping and kneading operations. The fluid pitch has a density of 10 pounds per gallon, and is delivered in special tank cars with a capacity of 10,000 gallons or 50 tons. The delivered price of $44.80 per ton HSP pitch multiplied by the unit usage factor of 0.11 tons per ton of metal, gives an estimated unit cost of $4.94 per ton of primary metal.

4. Aluminum Fluoride

The loss of aluminum from the cryolite melt ($3NaF.AlF_3$) requires that aluminum fluoride (AlF_3) be added at a rate of 60 ± 10 pounds per ton of primary metal. The material will be received in both bulk (50-ton covered, hopper-bottom rail cars) and bags (100-pound units in a 40-ton box car) to give adequate flexibility to the operation. A delivered price of 12.5 cents per pound aluminum fluoride gives an estimated unit cost of $7.50 per ton of primary metal for the 60 pounds per ton factor.

5. Cryolite

This is the primary component of the electrolyte bath and is consumed at a rate of 50 ± 10 pounds per ton of primary metal. At a delivered price of 12.5 cents per pound (bulk or bag) cryolite has an estimated unit cost per ton of metal of $6.25.

6. Fluorspar

This is a fluxing agent, required infrequently, that can be supplied by box car in bags because only 1.0 to 1.5 pounds fluorspar is needed per ton of primary aluminum. At a delivered price of 10 cents per pound, the unit cost will be 12.5 cents per ton of primary metal.

7. Soda Ash

Adjustment of the composition of the electrolyte melt requires that sodium carbonate be added to compensate for any changes from side reactions at both the cathode and anode. For example, hydrogen fluoride is generated from moisture that enters the cell reaction zone. Only an occasional box car of 100-pound bags will be needed to supply 2.50 pounds of soda ash (Na_2CO_3) per ton of metal. At a delivered price of 5.0 cents per pound, the unit cost of soda ash will be 12.5 cents per pound of metal.

8. Lime

Neutralization of the hydrogen fluoride in the off-gas from the pot lines requires 80 pounds of fresh pebble lime per ton of metal. At a delivered price of 5 cents per pound of lime, the unit cost is estimated at $4.00 per ton of primary metal.

9. Cathode Blocks

Although the carbon electrode manufacturers have not been able to gain entry into the aluminum industry anode business, there has been penetration of the cathode liner market. Pre-baked carbon blocks are made in different geometries for each customer's cell design. The nominal width is 20 inches, length from either 18 to

59 inches or from 59 to 100 inches, with a thickness of about 17-18 inches. A groove is provided in the block to accommodate the steel cathode rods that are about four inches in diameter for 90,000 ampere cells. The carbon blocks have a density of 1.67 grams per cubic centimeter. A list price of 11.40 to 11.90 cents per pound was obtained from one of the major suppliers.

For an average cell life of 36-40 months, the usage of carbon blocks would be 45.0 pounds per ton of aluminum metal. The unit cost on this basis would be 45.0 x $0.12 = $5.40 per ton of metal. This is a significant cost, relatively, but it is a convenient source of a reliable carbon lining. It eliminates the fumes and labor charges required for handling, mixing and baking of a monolithic lining from carbonaceous material and low softening point pitch.

The cathode lining "green mix" would cost about five dollars per ton of metal produced on an installed basis--including raw materials, labor, and other charges. A cell repair room is preferred to remove the old lining and install a new green lining. The tamping and baking-out of the green mix creates a problem in obtaining as dense and homogeneous a monolithic baked lining as with the blocks, which are cemented along the serrated vertical sides.

Since there are essentially no savings by captive manufacture of the cathode monolithic lining, it is recommended that the cells be repaired in place using purchased carbon blocks.

C. UTILITIES

1. Electric Power

A West Penn Power Company 138/132 KV aerial power line on the south side of the plant site will be tapped at a suitable point to meet the total power requirements. Three main lines will be provided for the two lines of reduction cells and other uses of electrical power such as carbon plant, casting house, and normal site facilities. Arrangements can be made with West Penn Power Company to install suitable circuit breakers and switchgear to meet regular operating as well as emergency conditions under the anticipated weather cycles.

Each reduction pot line will be served by a main power transformer to step-down the voltage from 138 KV to 13.8 KV. Suitable grounding, lightning arresters, and a regulating transformer are planned to feed an isolated area containing the rectoformer installation. A total of six rectoformers (transformer-silicon diode rectifier combination) are paralleled to supply the DC current at 120,000 amperes and up to 700 volts. One of the six rectoformer units can be removed from the line without disrupting the DC bus supply to each of the two pot lines.

The estimated breakdown for all electrical power is for an overall power factor of 95 percent:

Description	Connected Power
Pot Lines	163,000 KW
Process	8,000
Materials Handling	4,000
Site Facilities	10,000
Refrigeration	4,500
Air Compressor	500
Total Connected Power	190,000 KW

The estimated connected auxiliary power, other than the electrolytic reduction cells, is 27,000 KW. For this auxiliary power a load factor of 33 percent has been assumed for an average annual usage of 80 million kilowatt hours. Thus, for an annual metal output of 80,000 tons, the estimated auxiliary unit power usage is 1000 KWH per ton of aluminum.

The overall power requirement is the sum of 15,000 KWH per ton of primary metal for reduction plus 1000 KWH for all plant auxiliaries exclusive of pot line reduction cells. The total estimated power usage is 16,000 KWH per ton of metal. At a power rate of 3.9 mills per KWH, which is realistic from discussions with existing conditions in the area, the unit cost would be $62.40 per ton of ingot produced.

2. Natural Gas

A 50 percent non-interruptible supply will permit the metal casting house and the anode baking plant to be maintained in operation continuously. The other major load in the boiler house can be switched over to fuel oil as a standby during the winter months. Combination burners might also be considered for the cast house furnaces and the tunnel kiln if total interruptible supply is necessary.

Suitable pressure reduction and metering will be provided prior to distribution at 50 psig for the plant uses. Estimated usages are:

Building or Area	Gas Demand SCFM
Laboratory	5
Carbon Plant	25
Pot Lines	25
Boiler House	745
Casting House	350
Anode Tunnel Kiln	500
Total Demand	1650 SCFM

The estimated average usage over the year will be 1250 SCFM. For an average output of 7 tons metal per hour, the factor will be 10,700 SCF. The unit cost for a purchase price of 50 cents per 1000 CF of natural gas will be $5.35 per ton of metal.

An insulated (factory-wrapped) carbon steel, buried pipe line with welded joints will be carried below the frost line to distribution points.

3. Plant Water System

This will provide fresh potable water and make-up for process water from suitable wells. Treatment will be necessary to remove suspended solids and to control microbial and other undesirable organisms such as algae by chlorination. Fire water will be accumulated and held in an elevated tank with a draw-off at a level to provide a minimum storage of 200,000 gallons. A special block valve will be opened from this reservoir in time of emergency to feed the fire water distribution system at 1000 gpm and 125 psig. In addition, two fire pumps with gasoline engine drives will be installed at the river for standby emergency service.

An ultimate work force of 500 persons will require about 100 gallons per person daily of purified water for sanitary purposes. This is equivalent to an average supply rate of about 33 gpm of treated water over a 24-hour period.

Process water will be used as make-up water for scrubber recycling and cooling water uses. It must be clarified in all cases and, for boiler feed water, it must be deionized. Some chemical treatment of the process water might be done occasionally to eliminate marine organism growth.

A breakdown of the average daily process water requirement is:

Item	Maximum Demand GPM
Potable Water	50
Carbon Department	75
Bake Department	50
Rodding Department	25
Air Compressors	100
Scrubber Make-up	500
Total Demand	800 GPM

The estimated usage will be about 6000 gallons per ton of metal. Thus, a unit cost of $1.20 per ton of metal is estimated if the water can be supplied at 20 cents per thousand gallons.

4. Plant Air Supply

Two Ingersoll-Rand (200 HP Type XLE) compressors, each with a rated capacity of 1350 SCFM, will be needed to supply compressed air for process use. Suitable areas will be provided with special stations to remove oil from the plant air supply. Two Ingersoll-Rand

ESH two-stage compressors will supply 2x74 SCFM of clean instrument air for process control. A dehydration system will be installed for dehumidification of the instrument air. Estimated average loads are:

Garage	50	SCFM
Cast House	250	"
Laboratory	25	"
Bake Plant	100	"
Carbon Plant	250	"
Scrubber	25	"
Shop	200	"
Docks	200	"
Pot Lines	600	"
Instrument	300	"
TOTAL	2000	SCFM

The unit cost for the plant air supply is included in other charges for power to drive the compressors and miscellaneous supplies to remove oil, dehydrate instrument air, and miscellaneous filters.

5. Steam Requirement

Process steam is negligible in comparison with the heating and ventilation load. Since the introduction of circulating water systems to serve as a hot-water source during the winter, and chilled-water during the summer, the steam generator might operate the year-round. The refrigeration compressor can be driven by a steam turbine or electric motor during the summer months, i.e., the regional cooling season. In this case, the cost of electrical power to compress the refrigerant is believed to have an advantage.

The circulating water system will be operated all year to provide conditioned air to all working spaces for office, laboratory and control room personnel.

Process working areas will not be air-conditioned but will be adequately ventilated. A minimum dry bulb temperature of 70°F. will be maintained during the winter by unit heaters and 105°F. maximum during the summer by introduction of fresh outdoor air. Offices and control rooms in these process areas will be air-conditioned, however, to provide comfort-zone conditions.

For estimating purposes, the assumed steam requirements are:

Item	Steam Peak Load, lb/Hr.
Gate House	750
Administration	1500
Locker Room	4000
Laboratory	150
Docks at River	2500
Warehouse	2500
Shop	2500
Bake Plant	2000
Rodding Plant	2600
Pot Lines Offices	1000
Water Treatment	500
Total Steam	20,000 Lbs./Hr.

The unit cost for steam for all of these uses will be $2.00 per ton of metal based on an estimated load factor of 70 percent peak load and a unit fuel cost of 50 cents per thousand pounds of steam generated.

6. Total Utilities

The combined charges for all of the utilities described is:

Power Pot Line	-	15,000 KWH @ 3.9 mills	=	$58.50
Power Auxiliary		1,000 KWH @ 3.9 mills	=	3.90
Electrical Power				62.40
Natural Gas	-	10,700 SCF @ 50¢/M	=	5.35
Water	-	6,000 gal. @ 20¢/M	=	1.20
Steam	-	2,000 lbs. @ $1.00/M	=	2.00
Air	-	300 SCF - No Charge		--
Utilities, Unit Cost/ton metal			=	$70.95

Two steam generating units with a nominal capacity of 12,500 pounds per hour will be installed to supply dry, saturated steam at 150 psig. Combination burners for natural gas, with a heating value of 1100 BTU per cubic foot, or Number 2 fuel oil will be installed. Two storage tanks, each with a capacity of 150,000 gallons for fuel oil reserve in the event of emergency, will be provided near the boiler house.

Make-up process water will be 40 gpm on a once-through basis. The boiler feed water must be treated by conventional methods until it is softened (deionized) to acceptable total solids and hardness values.

Only one boiler house or utility plant operator is required per shift to maintain the desired conditions.

D. OTHER MATERIALS

1. Maintenance and Repairs

This can be assumed equal to the total direct labor charges for hourly maintenance workers. This relationship is based on experience in the metallurgical refining industry. A mechanical crew of 44 men plus 8 helpers in the bull gang will require an annual payroll of $403,200 (see page IV-7) or $5.04 per ton of primary aluminum metal produced.

2. Miscellaneous Supplies

These are estimated for office, laboratory and safety supplies by taking one-half the annual payroll for the plant organization exclusive of direct operating and maintenance labor. From Section IV-A, the payroll charges, exclusive of hourly workers, will be $1.541 million. Thus, the miscellaneous charges will be $0.770 million, which is equal to $9.65 per ton of metal.

3. Packaging and Shipping

This will consist of paperboard, wood, kraft paper, and steel strap for the various types of primary aluminum metal (pigs, sows, billets, ingot, etc.) that will be shipped in pure or alloyed form. An estimated average charge of $3.00 per ton of metal will cover pallets of pigs, or crates of other shapes, in addition to that metal shipped in an unprotected condition. Hot metal shipments eliminate this charge but incur a financial charge, indirectly, if new equipment must be purchased for transport of hot metal.

E. DIRECT PLANT EXPENSE

1. Local Taxes

Data supplied by the Industrial Development Group of West Penn Power shows that a tax rate of 65 mills is applied for the assessed valuation. This applies only to buildings and land and does not include process equipment, furniture, or machinery. The improved plant site and buildings will have an estimated cost of about $25 million. An assessed valuation will be about $10 million so that the annual charges for local taxes will be $650,000, or $8.15 per ton of metal.

2. Insurance

A premium of one-quarter of one percent is estimated to carry the necessary fire protection. The total capital investment is estimated at $77 million so that the annual premium will be $167,500. This is equal to $2.09 per ton of aluminum produced.

F. INDIRECT PLANT EXPENSE

This includes general home office or corporate expense that must be allocated to the respective operations to cover administration, sales expense, product distribution, technical service, engineering, and central research and development. The range for indirect expense in the electro-chemical industry is 7.5 ± 2.5 percent of gross sales income. In 1964, the annual report of the Aluminum Company of America (ALCOA) showed the indirect expense charges to be about 12 percent of gross income. The other primary metal producers reported sales and administrative expense from about 9 to 12 percent of gross sales.

This can be expected because considerable emphasis is placed upon developing new alloys and fabricated products, as well as upon the basic processes for conversion of bauxite to pure alumina and reduction of the latter to primary metal. The ratio of total sales dollars to ingot dollar value is about 2:1. An acceptable distribution of the indirect expense, on the basis of sales dollars, might be 7.5 percent on the metal ingot and 16.5 percent on the fabricated items.

For this reference design, which is conservative, it is felt that a value of 7.5 percent can be used.

Special effort will be placed upon manufacturing special alloy compositions and shipping "hot metal" in a pure form ready for casting into finished shapes or into 7-inch to 15-inch billets. The latter can then be reheated, if necessary, prior to extrusion, into suitable structural shapes.

Thus, on an estimated gross annual sales of about $40 million (80,000 tons at $500 per ton), the indirect plant expense would be $3.0 million, or a unit cost of $37.50 per ton of metal. As production is increased above the reference design capacity of 80,000 tons per year, the indirect expense might be reduced. Therefore, if an ultimate sales volume of 240,000 annual tons were achieved, the unit indirect expense might be reduced to a value of $30.00 per ton of primary aluminum ingot. Increased competition, however, might raise the unit indirect expense to $50 per ton of metal so that process changes or an ingot price increase would be necessary to absorb the added cost.

G. OPERATING COST ESTIMATE

From the previous sections, an estimated total unit manufacturing cost of about $405 per ton of metal (20.25 cents per pound) has been estimated for an initial plant of two pot lines to make 80,000 tons per year of aluminum metal. The capacity of the reference design was increased from 60,000 to 80,000 annual tons by employing a higher amperage in the pot lines. The standard direct current was increased from 90,000 amperes to 120,000 amperes on the basis of new smelter pot lines now being installed.

Addition of a third line in the space provided in the reference design would boost the aluminum ingot capacity to 120,000 tons per year, double the nominal design capacity used during the Phase II Feasibility Study for ARA. The effect of capacity on the fixed unit manufacturing cost has been illustrated by the need to plan on a minimum annual capacity of 80,000 tons of metal for a new installation.

A breakdown of the unit manufacturing cost for the two-line, 80,000 tons per year plant is given in Table A (page IV-36). Increasing the output of the Reesedale smelter above this reference design capacity of 80,000 tons per year can be done by adding an additional line of 40,000 annual ton capacity. Thus, the available plant site will accommodate equipment to deliver 120,000 annual tons metal.

TABLE A

PRIMARY ALUMINUM METAL

Estimated Unit Manufacturing Cost
80,000 Tons per year Output

Item	Unit	Factor	Unit Price	Unit Cost/ Ton Metal
Pure Alumina	Ton	1.92	$65.00	$125.00
Calcined Pet. Coke	Ton	0.50	35.00	17.50
HSP Pitch	Ton	0.11	44.80	4.94
Aluminum Fluoride	Lb.	50.	0.125	6.25
Cryolite	Lb.	60.	0.125	7.50
Fluorspar	Lb.	1.25	0.10	0.125
Soda Ash	Lb.	2.50	0.05	0.125
Pebble Lime	Lb.	80.	0.05	4.00
Cathode Blocks	Lb.	45.0	0.12	5.40
Total Direct Materials - Sub-Total				$170.84
Power (Pot Lines)	KWH	15,000	0.0039	$ 58.50
Power (Auxiliary)	KWH	1,000	0.0039	3.90
Natural Gas	MCF	10.7	0.50	5.35
Plant Water	MGal.	6.0	0.20	1.20
Steam	MLb.	2.0	1.00	2.00
Total Utilities - Sub-Total				$ 70.95
Other Materials and Supplies				$ 17.65
Direct Operating Labor ($1.252 million)				15.60
Other Labor ($1.944 million)				24.30
Payroll Burden (25% all labor)				10.00
Local Taxes and Insurance				10.24
Other Direct Costs - Sub-Total				$ 77.79
TOTAL DIRECT PLANT COST				$319.58
Depreciation (5% $77.836 million)				48.00
Indirect Expense (7.5% Sales Price)				37.50
Total Overhead - Sub-Total				85.50
TOTAL MANUFACTURING COST - Dollars/Ton				$405.08
TOTAL MANUFACTURING COST - Cents/Lb.				20.25

It is felt that adequate space is available adjacent to, or near the proposed Reesedale Site, to install a mirror-image of these three potlines. This would permit an ultimate plant to be built with a capacity of 240,000 annual tons of primary metal. This is about 8 percent of the 1964 total domestic production of 3 million tons.

The effect of increased plant capacity on the unit manufacturing cost is given in Table B.

The capital expenditure for the reference design and the expansions are (See Section III):

Annual Capacity	Total Investment
80,000 tons per year	$ 77.836 Million
120,000 tons per year	$102.080 Million
240,000 tons per year	$181.190 Million

The variable costs used in the preparation of the data in Table B are $241.79 per ton metal for direct materials and utilities. The fixed costs were changed only to increase the hourly operators and mechanics for each new pot line.

The carbon plant will require an additional 15 men to operate on a 7-day, 3-shift basis. The additional pot line will require 4 x 10 men per shift or 40 total. The cast house will need another 16 men total or 4x4 men per shift. The total additional operating crew will be 71 men for the estimated annual wages of $481,000.

The maintenance crew will add another 11 mechanics and 20 from the bull gang to fill in at various jobs in the plant services. These 31 additional workers will expand the annual payroll by an estimated $196,800. The plant organization would be increased from 430 people to 532, and the annual payroll from $3.197 million to $3.875 million.

The fixed charges will be reduced for several items but depreciation is the only cost element that changes significantly. The total estimated unit manufacturing cost, however, is lowered from $405.08 to $383.99 per ton by adding the third pot line to increase the annual aluminum ingot output from 80,000 to 120,000 tons.

If an equivalent operating unit of three pot lines is added at a later date, then the unit manufacturing cost is lowered to $365.14 per ton of ingot. It is suggested that the Reesedale Site be studied carefully so that an ultimate plant of 240,000 annual ton capacity can be built. This capacity appears to be the optimum for present metal reduction techniques at a site adjacent to the marketing area of the northeast quadrant.

TABLE B

PRIMARY ALUMINUM INGOT

Estimated Unit Manufacturing Cost

Effect of Plant Capacity

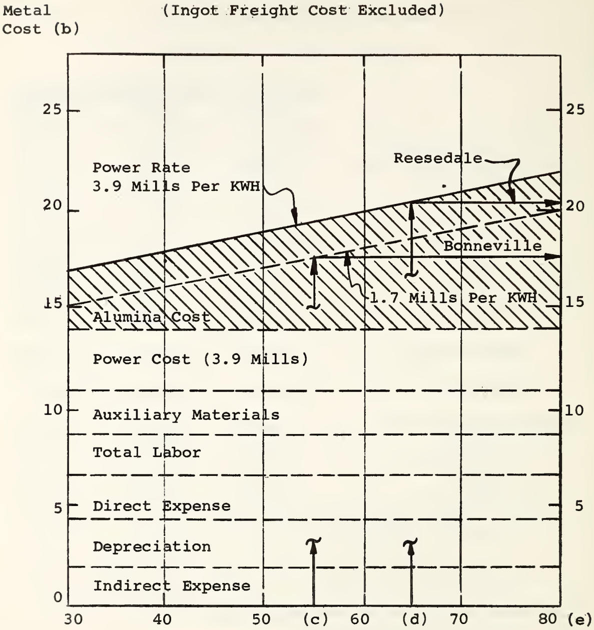
Item	Metal Output, Annual Tonnage 80,000	 120,000	 240,000
Direct Materials (a)	$170.84	$170.84	$170.84
Direct Utilities (b)	70.95	70.95	70.95
Other Materials	17.65	17.65	17.65
TOTAL FIXED	$259.44	$259.44	$259.44
Direct Labor	15.60	14.40	14.40
Other Labor	24.30	17.80	12.50
Payroll Burden	10.00	8.05	6.35
Local Taxes	10.24	7.50	4.05
TOTAL VARIABLE	60.14	47.75	37.70
PLANT COST	$319.58	$307.19	$297.14
Depreciation	48.00	41.80	35.50
Sales Expense	37.50	35.00	32.50
OVERHEAD	85.50	76.80	68.00
TOTAL COST, Dollars/Ton	$405.08	$383.99	$365.14
Cents/Lb.	20.25	19.19	18.75

(a) Alumina at $65.00/Ton delivered
(b) Power at 3.9 Mills/KWH

FIGURE D

PRIMARY ALUMINUM SMELTER

Unit Manufacturing Cost (a)
(Ingot Freight Cost Excluded)



(a) See Table A, Page IV-36.
(b) Unit Manufacturing Cost, Cents per Pound for metal cost.
(c) Estimated for Pacific Northwest (Imported Alumina).
(d) Estimated for Reesedale (Purchased Alumina).
(e) Delivered Cost of Alumina, Dollars per Ton.

V. FINANCIAL ANALYSIS

A. MARKETING BACKGROUND

Despite the usual cyclical nature of the metals industry during the last 25 years, aluminum metal has demonstrated a remarkable growth rate. Almost ten times as much metal is made today as was produced in 1940. It is significant that aluminum has become the major non-ferrous metal, replacing copper that had been the primary base metal. It must be pointed out that aluminum shows every sign of its ability to maintain a growth rate above that of the gross national product (see Table C on page V-2.

Although primary aluminum metal production was slightly above the nominal plant capacity in the United States during the last half of 1964, this was the first year in almost a decade that showed a balance between supply and demand. In the period 1950-58 there were three rounds of government-sponsored expansion of primary metal production capacity. As a result, the aluminum industry has shown significantly reduced earnings over the last 6-10 years. This can be seen from a review of the annual reports for the three major integrated companies (ALCOA, Reynolds and Kaiser), as well as the five other aluminum producers. Over-expansion in both metal reduction

TABLE C

U.S. SUPPLY OF ALUMINUM

Million Pounds

Year	Domestic Primary Production	Primary Imports Total	Domestic Secondary Recovery-Total (1)
1942	1,042	213	393
1943	1,840	271	628
1944	1,553	201	651
1945	990	665	597
1946	819	83	556
1947	1,144	31	690
1948	1,247	166	574
1949	1,207	155	362
1950	1,437	354	487
1951	1,674	245	585
1952	1,875	256	609
1953	2,504	602	737
1954	2,921	443	626
1955	3,131	395	828
1956	3,358	462	856
1957	3,295	451	890
1958	3,131	511	708
1959	3,908	480	898
1960	4,029	309	876
1961	3,807	398	970
1962	4,236	622	1,164
1963	4,625	831	1,516
1964	5,000	750	1,850

(1) Data are recoverable metal content for estimated total scrap consumption, as estimated by the Bureau of Mines. Apparently these do not include most of the imported scrap. Scrap imports have been included in the table at 90 percent of the amounts imported.

facilities, as well as the extrusion of structural shapes and fabrication of finished consumer products, resulted in a situation that depressed the quoted metal ingot price for 99.5% pure aluminum from 26.0 cents per pound in 1960 to 22.5 cents per pound in 1963. During 1964 it was possible to return to a profitable price in a series of one-half cent incremental increases to 24.5 cents per pound by January 1, 1965.

Thus, it now appears that the aluminum industry has regained its unprecedented market potential in all areas of application--transportation, construction, electrical, consumer durable goods, packaging, machinery and equipment, and miscellaneous uses. The growth rate for the primary aluminum industry has averaged 7 percent annually since 1952, about twice the rate of the overall production index reported by the Federal Reserve Board. Research and development have resulted in many new products and special alloys for both commercial and military application. A major application since 1952 has been in the form of aluminum foil, shipments of which have risen 11 percent annually. Other products with high growth rates are extruded shapes, 10 percent; die castings, 8 percent; sheet, plate, wire and cable, 6 percent.

It is estimated that shipments in 1965 will increase 10 percent over 1964, as a result of the overall growth in primary metal production and the attention being devoted to uses of aluminum by all major industries. Building and construction applications, especially siding, windows, and architectural decoration will be increased. The automobile industry now consumes almost 80 pounds per car of both the regular and anodized types of aluminum items. The electric power and communication equipment industries will find that extra tonnage will be needed. One example is the proposed EHV (extra high voltage) transmission lines. Transportation units include rail freight cars, commuter-train coaches, and truck-trailer bodies. This is a significant market segment that is expanding rapidly. A table of the uses forecast for 1965 and 1970 is:

Market	Usage Forecast Millions of Pounds 1965	1970
Building & Construction	1820	2280
Transportation	1930	2500
Electrical	710	900
Consumer Durables	750	940
Packaging	550	900
Machinery	530	730
Miscellaneous	920	1020
Estimated Total	7210	9270

The net overall shipments of metallic aluminum are calculated from the primary ingot produced, the secondary metal recovered, the imports of ingot and mill products and the exports of ingot and mill products. The overall trends are:

	Millions of Pounds		(a)
	1960	1964	1965
Shipments (b)	4733	7100	7810
Primary Ingot	4029	5100	5400
Secondary Metal	885	1435	1550
Imports Ingot	309	855	990
Imports Fabricated	83	120	135
Exports Ingot	570	420	450
Exports Fabricated	47	160	175

(a) Estimated

(b) Inventory changes account for difference between shipments and total net supply.

There are eight producers of primary metal that operate 24 reduction plants. About 70 companies recover secondary metal from scrap; several hundred firms manufacture drawn, extruded and rolled products; and over one thousand plants pour castings.

In general, aluminum has displaced steel in many areas because of its low-density, corrosion resistance, and attractively finished surfaces. This has been most evident in the transportation field and, also, by applications in the area of building and construction materials. The advantages of aluminum trailers in the trucking industry has been followed by significant penetration by aluminum in the manufacture of railroad freight cars, commuter cars, and rapid-transit cars during the last five years. Introduction of 100-ton capacity covered hopper-bottom cars, for example, has demanded the use of aluminum. Its unique physical and chemical characteristics permit more efficient haulage operations with a resulting lower unit cost per ton of material moved.

There is evidence that the advantages of aluminum would be utilized in combination with other materials, as has been done in the container and packaging fields. The development of an aluminum-clad stainless steel utensil is an example of a combined metal product. Food containers and some galvanized steel products have been replaced by aluminum-coated steel. Also, aluminum-base alloys with special properties, which have been developed for military and space application, are now finding commercial application--especially the high-strength alloys. The architectural uses of aluminum are expanding after many years of research and development combined with the need to erect multiple-story structures to achieve the optimum conditions of appearance, cost, safety and maintenance.

B. ALUMINA SUPPLY

This is the basic raw material that has created dramatic activity in acquisition of foreign bauxite deposits over the last ten years. Major exploration programs were conducted on each continent to find adequate bauxite ore reserves in order to supply the aluminum reduction facilities. Since the growth rate for aluminum is world-wide, there was a universal need for suitable bauxitic ores that could be mined and treated to manufacture high-purity aluminum oxide with a minimum of 99.0 percent alumina (Al_2O_3) and a maximum of certain impurities such as silicon, iron, sodium, titanium and water.

As a result of this geological exploration program, the world reserves of bauxite were increased by a factor of 350 percent during the period 1950-1964. Over 50 percent of the world's supply of raw bauxite ore is mined from deposits in the Western Hemisphere with major operations in Jamaica, Surinam and British Guinea. About 30 million tons of bauxite was mined throughout the world during 1963 and 82 percent was converted to primary aluminum metal. Roughly, four tons of bauxite ore (50-60 percent alumina) are required per ton of metal. Only five percent of the world production is mined domestically (in Arkansas). As a result, there has been an increase in imported bauxite from one million tons in 1945 to nine million tons during 1964. Bauxite for both abrasives and refractories manufacture must be imported from selected deposits to meet the rigid specifications for quality control of these products.

Eight major alumina complexes have been built in the Western Hemisphere and expanded to convert both domestic and foreign bauxitic ores to calcined alumina and aluminum chemicals. The plants based on imported bauxite have been concentrated on the Gulf Coast to take advantage of inbound ocean-going freighters and outbound barge or rail shipments of alumina. Significant quantities of aluminum metal are also made at these sites because low-cost fuel was available under a long-term contract for generation of electric power. The metal produced at the Gulf Coast sites is consumed, preferably, in the southeastern and Gulf Coast states marketing area to realize the minimum freight charges for ingot to mills and fabricators.

Over the last ten years, the United States government has accumulated a bauxite stockpile of roughly 15 million tons. This is adequate to meet the annual requirement estimated for 1965 aluminum metal production. In general, however, there is now significant world-wide expansion not only in the western hemisphere alumina operations, but also, in Africa and Australia to build up adequate sources of alumina for the free world. There is considerable bauxite mined in Europe, for example, in France, Italy, Yugoslavia and Hungary. Asia is scheduled to expand mining of bauxitic ores in the next few years, especially in Indonesia and Malaysia. Australia, too, is rapidly becoming a large miner and converter of bauxite to alumina.

The estimated manufacturing cost of alumina is about $40 per ton at the foreign mine site. To this cost must be added a maximum ocean freight of $10 per ton so that the delivered cost is no more than $50 per ton. A profit of $15 per ton before taxes is needed to pay off the heavy investment for mining, refining, and shipping facilities at the foreign ore site.

Chemical grade bauxite with 60 percent alumina (6% SiO_2 and 1.25% Fe_2O_3 maximum) can be purchased in British Guinea for $7.25 per long dry ton F.O.B. vessel. The delivered price at an Atlantic port F.O.B. rail cars is $13.95 per ton. Thus, from South American sources the freight plus handling charges is estimated at $6.70 per ton.

The reported average value of imported bauxite was $10.40 per ton for 9,170 million tons in 1963. Alumina used only for reduction to aluminum metal is imported duty free. There is a tariff of five dollars per ton on calcined bauxite and pure alumina for uses other than for metal production. Bauxite and alumina tariff rates are reviewed periodically by Congress.

Over five million tons of calcined alumina was produced in Western Hemisphere refineries during 1963 so that the factor for conversion of bauxite to alumina is about 1.80 to 2.0 long tons per net ton of alumina. This agrees with an assay of 55-58 percent alumina, assuming a 95 percent overall recovery at the alumina refinery. The Gulf Coast operations will continue because they have been expanded to production units with capacities of several thousand tons per day of alumina. New deposits, however, outside of the Western Hemisphere require a longer haul by ocean vessel so that alumina will be made at a suitable location, as close as possible to the mining activities, or at a location where low cost power is also available for reduction of the alumina to metal. Some underdeveloped countries have granted permission to refine the bauxite and in a few cases reduce the alumina to metal. Ultimate ownership, however, will revert to the nation possessing the bauxite deposits, after an extended operating period of 25-50 years.

In addition, there has been considerable activity in the Caribbean Area to build alumina complexes. These include bauxite mining, ore haulage to the mill site, an alumina refinery, and port facilities to ship alumina via captive ore carriers to the United States. From a rough cost survey, it is evident that freight charges for ocean transport have increased significantly. Thus a substantial savings can be realized if alumina instead of raw bauxite ore is shipped to the United States.

Another factor is the refining cost for alumina that makes it desirable to take advantage of the significantly lower labor rates outside the United States. Lower costs are usually also obtained for the direct plant expense items that include plant overhead and local taxes. The minimum optimum size of an alumina refinery is about 200,000 tons per year. This would correspond to a mining operation of about 1100 tons per day of dry bauxite ore.

Announcements over the last two years indicate that the average total investment for an alumina complex will be about $250 per annual ton of pure alumina. This includes installation of all the necessary buildings and equipment for mining, ore haulage, alumina refinery and port facilities. To justify this capital expenditure the need for property control of an adequate bauxite deposit with an estimated life of 50-75 years is imperative. Thus, a ten per cent nominal return on the investment (before tax) would be $20 per ton of alumina.

For marketing purposes, at least a ten per cent net income before tax must be used by merchant suppliers of pure alumina in order to establish a fair selling price. For captive use, however, this profit can be deferred and the basic raw material transferred to the aluminum smelter at its mill cost plus delivery charges. Depletion allowances can be calculated by the applicable foreign and domestic laws to obtain the maximum tax benefit. It is apparent that the aluminum industry, like other segments of the metal industry, requires an integrated operation to compete in a field that has such a high capital investment (about $1250-$1500 per annual ton of metal) to construct its complex mining, chemical refining, and reduction operations.

There is not an open market price quoted for metallurgical grade alumina because it is, essentially, a captive item. Our estimated unit manufacturing cost for pure alumina is $67 per ton in comparison with a delivered price of $55 per ton (see Page V-20).

Anaconda Aluminum (a division of Anaconda Copper Company) has announced its plans to proceed with a facility to manufacture 200,000 annual tons of alumina from Georgia clays. This can be justified on the basis of purchasing alumina at $65 per ton on the Gulf Coast and adding about $12 per ton for rail freight to Columbia Falls, Montana, for an estimated delivered price of $77 per ton of alumina. The added cost for pure alumina is about $23 per ton of metal. An extra ingot freight charge of about $12 per ton is necessary to bring primary metal into the Midwest markets. These are offset by a power savings of $35 per ton because the power rate is 1.68 mills per KWH. It was emphasized by Anaconda that engineering estimates showed the alumina refined from Georgia clays could be delivered to Montana at no increase in cost. Anaconda eventually will use Montana clays to save the finished alumina freight haul. A depletion allowance of 23 per cent can also be taken for a domestic mining operation of aluminous ores.

The high annual output of pure alumina has permitted the unit fixed costs for labor, expense, depreciation and overhead to be reduced so that the average unit manufacturing cost for alumina has not increased significantly over the last ten years despite an increase in the variable costs. Since alumina is the basic raw material for aluminum metal, each change of $10 per ton alumina delivered price is equivalent to 1.0 cents per pound of primary metal. Thus, ALCOA would realize an annual savings of $1.6 million if the delivered price of its alumina were reduced by $10 per ton.

A massive deposit of high-grade bauxite ore is needed to guarantee an adequate supply of this basic raw material, the market for which is growing at an annual rate of 5-7 per cent. In addition, however, the mining and refining of the bauxite to produce pure alumina demands every possible process economy to protect a producer's market position. Ocean transportation and subsequent barge or rail car haulage charges require 10,000 to 30,000 ton movements, by suitable ore-carriers and inland or ocean barge shipments to obtain the minimum delivery charges. Reynolds Metals has a fleet of six 30,000-ton vessels plus three 7500-ton ocean-going barges for movement of bauxite and/or alumina.

Pure alumina is estimated to represent about 35 per cent of the total manufacturing cost for primary aluminum, so that every effort is made to derive and to maintain the minimum charges for this primary cost element. This accounts for an aggressive exploration and land-lease program (mineral rights) to establish suitable and acceptable deposits of bauxite.

C. ALUMINA MANUFACTURE AT REESEDALE

The opportunity to establish a primary aluminum operation at Reesedale has been studied to create the maximum possible employment opportunities for the Armstrong County Area. Although it is doubtful that the manufacture of alumina at Reesedale can be justified, the conditions under which a "break-even" situation might be achieved can be established by a cost study.

From contacts with both the aluminum and transportation industries, it appears that pure (metallurgical grade) alumina can be delivered at Reesedale for no more than \$65.00 to \$70.00 per short or net ton. This includes \$60.00 to \$65.00 f.o.b. Atlantic Port purchase price plus \$5.00 for handling and rail freight from a port such as Baltimore, Maryland. The annual requirement for 80,000 tons of metal would be 160,000 tons of pure alumina. On a five-day week, this would be an average of about 650 tons per day, or 6.5 x 100 - ton special, covered hopper cars entering the gate five days per week. To take advantage of the special commodity rates for minimum 1000-ton and 2000-ton shipments, however, it would be necessary to send 10 to 20 x 100-ton car shipments via railroad from the port of entry to the plant site. A fleet of 50 to 60 100-ton cars would suffice for this service.

It was learned that the lack of suitable dock facilities along the Middle Atlantic Seaboard to accommodate 30,000-ton shipments of highly refined material, such as pure alumina, was one reason that rail transfer has been unable to compete with inland barge shipments. Storage silos at the receiving port would be necessary for 60,000 to 100,000 tons of pure alumina to receive one 30,000-ton boatload every 60 days and to transfer about 15,000 to 20,000 tons per month via rail to Reesedale. The ocean carriers can be unloaded automatically so that the turn-around time is usually less than 24 hours. Contamination of the alumina must be prevented during receiving, storage, and transfer to 100-ton covered-hopper rail cars.

One benefit of a port facility for pure alumina is that equivalent handling techniques are demanded for calcined bauxites consumed by the abrasives, ceramics, and refractory industries. The demand for high-duty, alumina-enriched, refractories has increased markedly during the last two years so that the demand will double every two to five years. The basic oxygen process for steel has placed a more rigid specification on the furnace lining material. Pure alumina has been added to the high-duty refractory material to increase the melting point because insufficient refractory grade bauxite is available for this purpose.

If the receiving port were provided with appropriate handling facilities for supplying pure alumina, to both the metallurgical and refractory consumers, special commodity rates might be approved to deliver this basic raw material to Reesedale at a rate equal to that for the final haulage leg via river barge. Mining and haulage charges for imported bauxite ore delivered to Reesedale are estimated at $10 to $15 per short ton:

CAPTIVE BAUXITE (CARIBBEAN SOURCE)

	Unit Cost Per Ton
Open-Pit Mining	$ 1.00 - $ 2.00
Mine Development	1.00 - 2.00
Haulage to Port	1.00 - 2.00
Ore Delivered to Dock (Foreign)	$ 3.00 - $ 6.00
Ocean Carrier Total Charges	2.00 - 4.00
Ore at Receiving Dock (Domestic)	$ 5.00 - $10.00
Transfer to Rail Car	1.00 - 1.00
Rail Freight (1,000 Ton Loads)	4.00 - 4.00
Delivered Reesedale, Per Ton	$10.00 - $15.00

The storage silo investment would be about $3 million. The fleet of 50 special 100-ton cars is estimated at about $0.75 million. This investment might be handled by the state or local industrial development authority if a municipal bond issue cannot be issued. Use of the dock and storage facilities along with the special covered-hopper rail car equipment can be arranged on a self-supporting or lease arrangement.

As might be expected, the Caribbean-produced alumina shows a lower delivered price in comparison with the Reesedale-manufactured alumina (See Table D, Page V-19). Even for a short haul from the Caribbean it is estimated that the delivered price of captive material (transferred at plant cost) will be $11.50 per ton lower if made at the Caribbean source. The combined freight charges are controlling cost factors so that the lower tonnage of refined alumina is preferable for movement by ocean carrier and the subsequent rail haul to the primary smelter. This estimate was made from data supplied in government reports. The auxiliary chemicals required per ton of alumina are 300 pounds of soda ash, 200 pounds of lime, and three pounds of starch. Natural gas is estimated at 12,000 cubic feet per ton and filter cloth at 0.60 square yard per ton. These items make up the combined unit cost of $6.50 per ton of alumina (see Page V-19). The estimated unit manufacturing cost at Reesedale is $66.50 per ton of alumina in comparison with $55.00 per ton for Caribbean-produced material shipped to Reesedale.

A summary of the rough cost estimates comparing

Reesedale with a Caribbean mine site is given below for an output of 200,000 annual tons of alumina:

	Dollars Per Ton	
	Plant Site Location	
Alumina Refinery	Caribbean	Reesedale
Captive Bauxite Ore, Delivered Price	$ 2.50	$12.50
Unit Ore Cost (2.0 Tons per Ton Alumina)	5.00	25.00
Auxiliary Chemicals & Utilities	6.50	6.50
Direct Materials	$11.50	$31.50
Direct Labor (1.0 Manhour/Ton)	3.50	3.50
Expense "A" (400% Direct Labor)	14.00	14.00
Unit Plant Cost	$29.00	$49.00
Depreciation (5% @ $200/Ton Capital)	10.00	10.00
Overhead (7.5% @ $100/Ton Sales Price)	7.50	7.50
Unit Manufacturing Cost	$46.50	$66.50
Ocean Carrier Charge	3.50	
Delivered U. S. Port	$50.00	
Transfer to Rail Car	1.00	
Rail Freight	4.00	
Delivered Reesedale Site	$55.00	$66.50

A depletion allowance of 15 per cent can be applied if the raw bauxite ore is derived from a captive mining operation. It would be applicable for either location so that it has been omitted from this particular site comparison.

This is the average estimated cost because it is based on $12.50 per ton delivered dry bauxite ore. At a $15.00 per ton delivered price for bauxite the estimated cost is $71.50 per ton - a disadvantage of $16.50 per ton relative to imported material.

One alternative that might allow a"break-even" situation is to find back-haul cargo space that can be utilized to give the same over-all total annual charges for bauxite as for alumina. For example, the unit train method for delivery of coal might permit back-haul of the bauxite ore at roughly one-half the cost for alumina via covered-hopper cars. An equivalent case is needed for the ocean transport, but this is an unusual requirement. Florida phosphate ore is exported from the United States for local fertilizer manufacture. Coal is the primary mineral exported from the Middle Atlantic Ports, but this commodity is not needed in the Caribbean Area. Mill products of aluminum metal, such as structural members and sheet, could be back-hauled for fabrication into building materials for the South American and Caribbean housing and industrial applications. There is an indication, however, that these countries, some in possession of massive bauxite deposits, now desire that an alumina refinery and/or an aluminum metal reduction facility be included in their long-term program of development.

In general, the advantages are with water transportation via the Gulf Coast Area for a back-haul commodity and river barge transfer to Reesedale. As a result, pure alumina is seldom imported from the bauxite sources. Also, economics favor the lower or middle Ohio River Valley Region for the optimum alumina freight charges, plus back-haul of metal ingot to the rolling mills and fabricators located along the Ohio Valley.

For imported alumina, however, the metal reduction facility might be located to permit equivalent barge rates by rail haulage from the receiving port. Then the power rate becomes the primary or controlling cost element. Another critical cost element is the freight charge for the outbound metal ingot to the rolling mill or fabrication center. These two factors account for the Evansville plant of Alcoa being expanded in 1965-66 with two additional 35,000 annual ton pot lines.

The Evansville plant location is adjacent to a captive rolling mill and, also, to a key casting consumer. In addition, it is in the vicinity of several independent fabrication plants of aluminum metal products. Power is generated by a private thermal plant that burns captive mined coal. This allows a maximum fuel cost of 10 to 12 cents per million BTU and, also, permits a depletion allowance for the coal mining operation. Alcoa has emphasized that new primary aluminum reduction facilities will remain in the Ohio Valley, or near an equally low-fuel-cost area for the generation of power from coal. Reynolds Metals has also arrived at the same conclusion on the basis of its intention to build a metal reduction plant in Kentucky near captive coal mines.

Thus, it is evident that the availability of new massive bauxite reserves in foreign areas has focused more attention on the other primary variables, power and freight charges for inbound raw materials and outbound ingot. As a result, the major aluminum producers now find coal-fired power plants have the best power rates in locations that show the lowest combination of freight rates.

Comment on the recent announcement by The Anaconda Company to extract pure alumina from clays is appropriate. This company always has been interested in the utilization of clays from its copper operation. Some clays have been discarded as tailings and others are found by its field geologists in the course of their exploration activities. The plans to build an alumina refinery in Georgia based on local clays was a surprise because emphasis had been placed, previously, on the low-iron content of Pacific Northwest clay minerals. Also, the statement that Georgia-derived alumina and that the long rail haul to Montana would be competitive with their current sources of purchased material (Kaiser's Gramercy, Louisiana, alumina plant).

Activity in the development of both new sources of alumina and new methods of primary metal production have been accelerated over the last ten years. Several processes based on acid-leaching followed by crystallization, roasting or solvent extraction have been studied in the laboratory and, also, in 1to 10-ton per day pilot plants to accomplish the difficult iron-aluminum separation for recovery of pure alumina from clays or non-bauxitic materials. In general, the reported Anaconda Process uses hydrochloric acid for leaching followed by conversion of the solubilized chlorides to oxides by roasting. The hydrogen chloride present in the off-gas can be recovered easily and recycled to the leaching step. The calcined product can be treated with caustic soda to recover the alumina as in the Bayer Process.

The Bureau of Mines has followed these developments closely and has estimated that pure alumina might be produced at $65 - $86 per ton in a 1000-ton per day plant using clay as the basic raw material. This is roughly the range estimated that Anaconda might pay for pure alumina - $65 per ton plus $12 freight for a total of $77 per ton delivered to Columbia Falls, Montana.

The mining of domestic clay deposits for alumina is desirable in that dependence on a foreign source is eliminated. In addition, a domestic mining and refining operation for alumina permits a 23 per cent depletion allowance. This might be taken on the "pseudo" sales price of the pure alumina consumed from a review of the annual reports of the major aluminum companies. An effective tax rate of about 32 per cent appears to be based on alumina valued at roughly $100 per ton, which would be equal to an estimated market price by our cost studies. The effect of depletion allowance on the cash flow derived from such an operation will be covered in Section V - Part J.

Conversion of domestic aluminous clays to pure alumina might offer the Kittanning area an opportunity to supply pure alumina not only to a primary aluminum smelter, but also to the high-duty refractory plants located nearby. There is a shortage of both pure alumina and refractory-grade bauxite for the oxygen steel making (OSM) process so that consideration of an alumina plant based on clay in Armstrong County is suggested.

D. POWER RATE

In general, aluminum reduction facilities have always been located near low cost sources of electric power. Also, it usually afforded an unusual opportunity to take advantage of long-term contracts that were offered. Some of the companies prefer all interruptible power to obtain the minimum rate, but normally a one to one ratio of firm to interruptible power is desired. Hydroelectric stations are considered reliable sources of power under normal conditions. Weather cycles, however, cause the water reservoir to fall below the desired minimum so that a power shortage develops occasionally.

Next to pure alumina, power is the major cost element so that the lowest possible power rate must be found. Until recently, hydroelectric power has been preferred by the reduction units because it offers the lowest over-all operating cost for generation of power. One disadvantage of hydro power today, however, is that it requires double the capital expenditure for the same megawatt power generation capacity. The operating and maintenance cost is lower by one-tenth of a mill than for a thermal electric plant--only 0.2 vs 0.3 mills per KWH. There is no fuel charge, but an adequate water supply is needed to maintain a minimum reserve to guarantee production. The long life of a hydro plant is almost double that for a steam plant so that the annual depreciation charge is about equal. The interest and amortization charges also will be about equal despite the debt incurred by the higher fixed capital expenditure.

The total estimated unit power generation cost is 0.9 - 1.5 mills per KWH for hydroelectric plants when the fixed charges are added to the direct operating cost. The remote geographical location of these plants requires that a premium be offered to the customer for locating a plant within 15 - 20 miles of the hydro station. Otherwise, the capital cost of a transmission line across difficult terrain plus out-of-pocket transmission charges must be added. The Bonneville Power Authority sells power to the Anaconda and Harvey reduction plants for 1.68 mills per KWH because these two plants are in the vicinity of a power plant. The other aluminum smelters in the Pacific Northwest pay 2.0 - 2.2 mills per KWH. Over 33 per cent of Bonneville's total capacity is consumed by the aluminum reduction plants in that region. A total capacity of 750,000 annual tons of primary metal is now installed. An additional 200,000 annual tons has been announced for construction.

Thus, hydroelectric power has always been an attraction for the primary aluminum smelters as illustrated by the original ALCOA dams in the Tennessee Valley (now operated by the TVA, the Massena (New York) reduction units in the St. Lawrence power project, which have replaced the old units at Niagara Falls, and the Canadian projects for ALCAN's operations in Quebec and British Columbia. Another source of low cost power was natural gas along the Gulf Coast as a fuel for steam-electric power generation. Both of these power sources lose their advantage, however, when new reduction plants are studied today.

The freight charges for the inbound pure alumina and the outbound primary metal ingot can be optimized by building a new reduction facility close to a mine-mouth, coal-fired, thermal generating station. OLIN was the first to show the potential of such a plant in the Ohio Valley and ALCOA followed with an equivalent facility near Evansville, Indiana. Reynolds Metals has recently announced a similar operation with a reduction unit planned for construction adjacent to a captive coal deposit in Kentucky (site as yet undisclosed).

A mine-mouth, coal-fired, steam-electric generating station eliminates the coal handling and haulage cost associated with rail freight charges for the coal. In addition, lease or ownership of the coal deposit allows for a depletion allowance when mining operations are carried out.

Of course, the improved technology of steam plants has permitted an increase in their nameplate capacity to 1000 - 1200 megawatt (MW) units. The boilers operate to deliver 3500 psig steam at 1000° - 1100°C at the throttle. The thermal efficiency is about 40 per cent because the presently available 1000 - 1200 MW units show a heat rate as low as 8250 BTU per KWH. In the last 25 years the improved heat rate has reduced the amount of coal required from 1.00 to 0.75 pounds per KWH for the newest and most efficient units.

The average price of coal delivered to the power station is about $4.00 per ton, in the Pennsylvania coal regions, which is equal to 18.2 cents per million BTU for a heat content of 11,000 BTU per pound of coal. The lower limit for coal delivered on a long-term contract is 10 - 12 cents per million BTU. Captive coal will be no higher than $2.75 per ton from an efficient mining operation or 12.5 cents per million BTU. At these two delivered prices for coal, the fuel cost would be 1.50 mills per KWH (for coal at $4.00 per ton) and 1.03 mills per KWH (for coal at $2.75 per ton).

Several plants have demonstrated a fuel cost for purchased coal at less than 1.5 mills per KWH. Since 0.25 to 0.40 mills per KWH for direct plant cost covering operation and maintenance has also been demonstrated, it appears that the direct plant cost for power will be 1.28 - 1.90 mills per KWH. The newer and larger single stations of 300 to 1000 megawatt nameplate capacity operate at 80 - 90 per cent of nameplate capacity (plant factor). In contrast, it is difficult to find a utility system serving both industrial and residential consumers with a plant factor above 50 per cent. West Penn Power in western Pennsylvania area has an over-all plant factor of 49 per cent, but its Reesedale power station operates at 82 per cent over the year.

How to meet the peak load demand during a 24-hour period and over the seasons of the year is changing the utilities from local independent power producers to regional systems connected by suitable interties to allow purchase of outside power for peak loads and for emergencies. Several alternates to the regional interties have also been used. These are standby generators powered by diesel engines, gas turbines, and hydro pump-storage reservoirs.

Consolidated Edison had a nominal total nameplate capacity of 6663 megawatts in 1963 and a plant factor of 38 per cent (22.2 billion KWH). West Penn Power Company in 1963 had a total capability of 1575 megawatts with a plant factor of 49 per cent for an annual output of 6.8 billion kilowatt hours. This example shows the need for Consolidated Edison to obtain additional power by its proposed 2000

MW pump-storage plant at Cornwall to meet peak loads and to purchase outside power to avoid building new generating stations in the metropolitan area.

Hydropower from Canada was being negotiated when Consolidated Edison decided to join a group in building large and efficient mine-mouth steam generating units in western Pennsylvania. Any source of outside power will be transmitted over EHV lines (extra high voltage of more than 375 kilovolts, both AC and DC current) as part of the proposed national EHV grids. These national networks will allow more efficient utilization of the combined national thermal and hydro generating capacity. Also, it will avoid outages created by unexpected peak loads or power failures during the summer and winter months by balancing the overall regional and national capability to meet the variable loads with optimum operation.

Although the unit variable cost for power is 1.28 - 1.90 mills per KWH (direct operating cost), the fixed charges consist of a significant amount depending upon the municipal and state regulations and the various taxes. In 1963 the West Penn Power Company reported a total fixed cost of 0.70 mills per KWH. About one-half of this unit cost was for depreciation, which was calculated on a basis of a 40-year life or about 2.5 per cent of the reported fixed capital assets for plant equipment.

By contrast, Consolidated Edison in 1963 reported a total fixed unit cost of 1.2 mills per KWH for generation, transmission and distribution of power within its metropolitan area. Depreciation by Con Edison, however, was also 2.5 per cent of its total fixed capital assets. One reason that the indirect unit cost for Con Edison is higher than for West Penn Power can be assigned to the 38 per cent plant factor, which is lower than the 49 per cent for West Penn. If both systems were operated at the same plant factor, Con Edison would show a unit fixed cost of 0.93 mills per KWH vs 0.70 for West Penn Power.

Thus, the plant factor is not only a critical variable for the direct plant cost, but also represents the key variable for distribution of the fixed charges that must be distributed over the KWH output. The proposed federal grid networks will require significant capital expenditures for the EHV intertie systems but, in general, will lower the average fixed charges by raising the over-all national plant factor. This is shown by the cost data below, based on a 40-year life on the capital expenditure of $125 per kilowatt capacity:

		PLANT FACTOR		
Item Description		90%	75%	50%
Fuel Cost	Mills/KWH	1.25	1.25	1.25
Operation Costs	" "	0.30	0.40	0.50
Direct Plant Cost	" "	1.55	1.65	1.75
Depreciation	" "	0.35	0.42	0.63
Fixed Charges	" "	0.53	0.64	0.96
Indirect Plant Cost	" "	0.88	1.06	1.59
Total Unit Cost	" "	2.43	2.71	3.34
Power Rate	" "	3.50	3.50	3.50
Net Before Tax	" "	1.07	0.79	0.16
Return on Investment	Per Cent	6.8	4.2	0.6

On the basis of these rough cost estimates, it is believed that power might be generated in a 1000 to 2000 megawatt, mine-mouth station in western Pennsylvania at a unit manufacturing cost of 2.50 to 3.00 mills per KWH. Transmission of this power to the densely populated region from Washington, D. C. to Boston will cost an estimated 1.00 mill per KWH. Thus, the delivered cost of power to the Con Edison territory will be about 4.0 mills per KWH. This purchase price is a"break-even" value for a suitable station to be erected in the New York Metropolitan Area operated on coal delivered by unit-train shipments to minimize the freight charges. The proposed power pool lowers the unit cost of power and might provide a potential power rate advantage for both present and future industrial customers in the Western Pennsylvania area.

From our discussions with representatives of some of the utility companies and industrial development groups in Western Pennsylvania and Ohio, we believe that an attractive power rate might be negotiated for a primary aluminum smelter. It appears, however, that captive power plants constructed by the aluminum companies, combined with their captive coal-mining operations, might be undertaken jointly with a public utility pool in order to furnish 100 to 1000 megawatt blocks of power to industrial customers at a competitive power rate. The latter was done in the Ohio Valley to supply power to the Portsmouth uranium isotope separation plant of the Atomic Energy Commission. This power pool is now serving as a valuable source of low cost power for its immediate region, as well as a source of supplementary power to other regions, for example, the Boston to Washington urban areas.

We understand that a power rate below 4.0 mills per KWH at the Reesedale site is optimistic. The power rate will depend upon the location of the smelter relative to the power plant or the main transmission line of the West Penn Power Company. Other factors are the megawatt demand by the smelter and the power factor. It is felt that a power rate of 3.7 mills per KWH is the lowest that might be arranged near one of the newer mine-mouth power plants. Also, the rate structure that has been established for industrial customers cannot be changed easily to accommodate a single customer with only a total of 120 to 200 megawatts load. For this reason, it is felt that many industrial firms build captive power plants although their actual generating or direct plant cost is above that for a utility.

Until suitable plans are made to attract new industry with long-term contracts for low-cost power at a competitive rate with other regions or programs, the current economic status of the Reesedale area will continue. The power rate alone, however, does not prevent Reesedale from becoming an optimum site for primary aluminum smelting because freight charges on inbound raw materials (by either rail or barge) and outbound primary metal are recognized as being significant major cost elements.

In order for the Pacific Northwest to attract aluminum reduction plants as the major customer for its hydroelectric power, a power rate of 40 to 50 per cent of that of the TVA (4.0 mills per KWH) region was imperative. The Anaconda Aluminum Company does not have a captive source of alumina so that it is purchased and brought in by rail at a delivered price of about $75 to $80 per ton. This is equal to an extra cost of $20 per ton of metal, which is offset by the power cost reduction of about $35 per ton of metal.

The differential freight charge of about $15 per ton of primary metal makes the delivered cost of primary aluminum ingot shipped into the northeast quadrant equal to that estimated for Reesedale-produced ingot.

Our conclusion that suitable sites for an aluminum reduction plant exist in southwestern Pennsylvania (reported in our Phase I and Phase II Reports) has been validated by the recent announcements of new reduction facilities located in the Ohio Valley. ALCOA is expanding and Reynolds plans to build a reduction unit in which captive electric power from captive coal will be generated. Also, these waterside plants offer the optimum schemes for transportation of both raw materials and outbound primary metal. The minimum freight charges plus captive power offer an advantage over their Pacific Northwest plants. The latter are felt to be the desired source for primary metal consumed in the region (Pacific Coast), but only reserve or standby units for metal to be fabricated in the northeast industrial quadrant, of which Reesedale is the geographical center, by the transportation, building products, and container-packaging industries.

One exception to this preliminary economic analysis is the proposed INTALCO aluminum reduction facility to be located at Bellingham, Washington. Construction of a single pot line with a nominal capacity of 76,000 annual tons of metal has been started and a second line of equal capacity has been approved. The low-cost Bonneville power offers an advantage for these high capacity single pot lines, the world's largest and double the normal line output. In contrast to the Caribbean source of alumina, however, INTALCO has planned to use Australian material that can be delivered to its tidewater plant. Thus, INTALCO found a cross-country haul of primary metal not to be an excessive freight charge when reducing Australian alumina with a power rate of 2.0 mills per KWH.

Harvey Aluminum Company has announced plans to build a new reduction facility with a capacity of 100,000 annual tons metal. Harvey has not finalized on a plant site location, however, because it is difficult to optimize the multiplicity of cost elements involved in a detailed engineering and marketing analysis. Harvey has a low-cost reduction unit at The Dalles Dam in Oregon (Bonneville Power Authority) with three rolling mills and fabrication plants; one at Torrance, California; one at Adrian, Michigan; and one under construction at Lewisport, Kentucky. In addition to this primary metal ingot distribution problem, Harvey has a Caribbean supply of refined alumina to come on stream by

1966-67. Harvey has been negotiating with many groups in order to achieve the combination of direct and indirect costs that will assure a competitive and a minimum unit manufacturing cost.

It might also be noted that ALCAN (Aluminium Company of Canada) has announced a 100,000 annual ton expansion of its KITIMAT operation in British Columbia to take advantage of its participation in development of alumina from Australian deposits. This only emphasizes the possible dominant position held by ALCAN according to some analysts (from a Drexel and Company report on The Domestic Aluminum Industry dated 1/12/65). With the lowest price for alumina, combined with the abundant and low-cost hydro power, plus lower operating costs than in the United States, it might be possible to show a "break-even" plant cost, without depreciation and other fixed charges, of 12 cents per pound. This would permit recovery of direct or "out-of-pocket" costs only and would not carry any indirect charges, such as depreciation and overhead, or allow for any profit. Of course, it must be remembered that the primary ingot merchant metal price is based on realizing a suitable profit. An integrated producer, however, might transfer ingot at the actual plant cost for fabrication into finished goods that generate the profit. The accounting system adopted depends upon many factors, among which is depletion and where it is applied.

In Figure D is a graph to show the effect of power rate on the unit manufacturing cost of metal at four different prices for alumina delivered to the reduction plant. It is possible to purchase Bonneville power as low as 1.68 mills per KWH, which is done by Harvey and Anaconda at two different locations. The other major hydroelectric power systems (TVA and St. Lawrence Power Project) sell power at about 4.00 mills per KWH. This is the same rate now offered by the utility systems in the coal mining regions of Appalachia and Ohio Valley. A captive power plant in this same region can generate power at a direct plant cost of about 2.00 mills per KWH, which is the average rate for the Bonneville Power Authority.

It will be shown, however, that a 12-year payout time and a 20-year period for capital recovery are only marginal by industrial standards in the financial analysis using discounted cash flow and net present value (see Page V-69 for summary of calculations for the four basic cases).

E. MANUFACTURE OF ANODE AND CATHODE BLOCKS

Calcined petroleum coke and other chemical reagents make up an estimated 12.0 per cent of the primary metal manufacturing cost. The major items are for captive production of baked anodes, purchased cathode blocks, and fluoride salts for the cryolite-rich electrolyte medium. The carbon plant represents a major capital expenditure and requires a large staff to carry out the many steps in mixing, pressing, baking, rodding and reworking spent anodes.

The basic raw materials for the anodes represent an incoming weight of about 60 per cent of the primary metal produced. Spent anodes that are reworked represent about 20 per cent of the metal output because only two-thirds of the baked anode is consumed per cell loading. The service life of a fresh anode is estimated at about 12 to 14 days.

It is understood that the process for anode manufacture has been improved by development of a tunnel kiln for the final baking operation. This continuous baking equipment is reported to reduce the capital expenditure, the operating labor, and the maintenance charges in comparison with those experienced in operating the gas- or oil-fired pit furnaces now installed. A few prototype kilns have been installed for demonstration and shakedown runs so that any design modifications can then be made for standard commercial units.

It was learned that carbon and graphite electrode manufacturers have never been able to justify entry into this anode business because of the freight charges on finished goods and the rework material. Thus, it is expected that decentralized and captive operations will be continued until a competitive aluminum reduction process has been demonstrated commercially.

A rough breakdown of the anode cost has been made to illustrate the magnitude of the difference between manufactured and purchased anodes. For a nominal 80,000 annual ton reduction plant, at least 56,000 annual tons of baked anodes must be prepared. It is planned to operate the carbon plant on a 5-day week at a finished anode output rate of ten tons per hour. From five to six tons of fresh calcined petroleum coke, two to three tons of recycled anode butts, and 2.5 tons of HSP coal tar pitch are mixed per hour. The hourly charges for these two raw materials will total about $300. To this is added $25 per hour for utilities. Direct operating labor for 15 men on each of the three shifts will cost about $50 per hour. Direct expenses at 600 per cent of labor will be $300 per hour. Thus, the estimated plant cost will be $675 per hour for ten tons of baked anodes. Depreciation at ten per cent on the $10 million investment for the carbon plant will be written off at $200 per hour. An overhead charge of $125 per hour will be added so that the total unit manufacturing cost is about $100 per ton of finished anode. Some reduction plants purchase green petroleum coke, which is then calcined in a rotary kiln on the premises or is used as a packing material in the anode furnace pits. The latter operation serves as a calcination step for that part of the green petroleum coke used as packing material.

Purchased carbon or graphite cathode blocks are 10 to 12 cents per pound so that the captive manufacture of the anodes can be done at no more than one-half the purchased material. This is an estimated annual savings of $760,000 before tax, which is adequate to justify the carbon plant investment of $10 million.

The auxiliary chemical reagents for the electrolyte are purchased from the leading aluminum producers. Aluminum fluoride and cryolite amount to about $14 per ton of primary metal produced. Thus, the major aluminum companies can save about 0.1 to 0.2 cents per pound of metal in comparison with an independent and smaller producer who purchases these materials.

Lime to neutralize the hydrogen fluoride, which must be removed from the off-gas (generated at the pot lines) by an efficient water (alkaline) scrubbing system, will require a chemical cost of about $4.00 per ton of metal. Operation, maintenance, and other charges will bring the total off-gas treatment cost up to at least $10 per ton of metal. This is 0.5 cents per pound of ingot that has been added during the last ten years to comply with local, state and federal air pollution regulations. It might be necessary to install suitable recovery units for reuse directly of the dry solids collected at the cells in the pot lines and indirectly for chemical treatment of the calcium fluoride pond solids to recover aluminum fluoride. Based on a physical loss of one per cent of the solids added to the pot lines, the estimated total value of the chemicals is about $1.25 per ton of metal. This is negligible relative to the other costs so that a modified scrubbing circuit would be required to utilize the hydrogen fluoride content of the off-gas. Conversion of alumina to aluminum fluoride by a suitable method might allow the off-gas treatment to show a break-even cost. This is normally all that can be expected from a pollution control measure.

F. DIRECT OPERATING EXPENSES

In general, the Reesedale area has an adequate and capable labor supply in all categories. Only a few experienced foremen and supervisors would be needed to insure bringing the reduction unit on stream at its design capacity. A startup period of three months is planned after a training period of three months. A total annual payroll of $3.196 million has been estimated for a plant organization of 430 employees. This is an average annual salary of $7,500, which compares with that reported by the Bonneville Power Authority for the aluminum workers in the Pacific Northwest. The annual output of ingot would be 186 annual tons per employee for the proposed 80,000 annual ton capacity primary metal reduction plant used in our reference design. This is a higher output per employee than the 1962 national average of about 154 annual tons per employee in all domestic reduction units. INTALCO has emphasized the design of the most completely mechanized reduction facility for its proposed Bellingham installation to derive the minimum unit labor cost. Thus, the estimated tonnage per employee (production worker) can be anticipated from process modification during the last five to six years.

It must be emphasized that the unit direct charges for operating labor, maintenance, supervision, chemical laboratory, and other direct expenses are more dependent upon the output of each cell in the reduction pot line than on other cost factors. An increase in the direct current above the nominal 90,000 amperes, now carried by most of the electrical bus bars from one cell cathode to the adjacent cell anode, was necessary for the proposed Reesedale plant. These direct fixed costs, made up of all production and service activities at the plant level, represent a significant segment of the operating cost in total dollars. The unit cost depends inversely upon the plant output. It was found that the basic reference design must be increased from 60,000 to 80,000 annual tons to bring the estimated unit manufacturing cost below 20¢ per pound of primary aluminum metal.

By assuming that a direct current of 120,000 amperes could be carried instead of 90,000 amperes in each of the two 140-cell lines it was possible to reduce the unit pot line labor cost. Also, this reduced the unit cost of the supporting and other direct charges because the total number of personnel was not increased. Since the proposed INTALCO facility is for 76,000 annual tons of metal in a single line, it is believed that an 80,000 annual ton plant at Reesedale (two 40,000 ton lines) is the minimum capacity that can be justified.

When the output is increased from two to three lines, for a total of 120,000 annual tons, the direct charges for all items except pot line labor are reduced proportionately. The ultimate unit cost of direct operating charges will be achieved when the plant reaches an annual output of 240,000 tons. This appears to be the reduction plant size that optimizes direct expenses. Several primary metal facilities exist with this capacity, but, until recently, the initial units were only 30,000 to 40,000 annual tons per line.

G. INDIRECT CHARGES

1. Depreciation - This is a major cost element that accounts for 12 per cent of the total unit manufacturing cost - about 2.4 cents per pound of metal. As a result, the fixed capital investment per annual ton of primary ingot is critical. Also, the rapid growth rate of the aluminum industry, averaging from six to eight per cent annually (equivalent to that of the electric power industry) requires that significant debt financing be arranged. The annual capital expenditures for the integrated aluminum companies is at least twice the net income after tax. It is usually equal to or greater than the total cash flow generated. As a result, these companies have significant long-term debt. Their stockholders' equity position is seldom more

than one-half the total capital assets because of the long term debt commitments.

Evidently, the accelerated or liberalized rates allowed, under both the revised government schedules and the certificates of necessity, have allowed more than the nominal amounts of depreciation and amortization to be taken during periods of peak sales and income. For this study it was decided to assume a straight line depreciation over an assumed 20-year useful life.

The reported new plant capital investment averages about $1,500 per annual ton of primary ingot for a 40,000 ton capacity unit, $975 per ton for 80,000 ton capacity, and $755 per ton for a 240,000 ton capacity. The auxiliary site facilities reduce the average fixed capital expenditure. Also, additional pot lines can be added for an average capital cost of about $600 per annual ton of metal.

The unit depreciation charge for the proposed 80,000 ton facility will be $48 per ton - or 2.40 cents per pound of metal. Reesedale has a penalty of at least $5 million for the site preparation work because of the abnormal site topography. This is equivalent to a penalty of 0.15 cents per pound of metal, or an annual charge of $240,000.

A consultant has investigated the new pyrometallurgical techniques for direct conversion of low grade aluminous materials (e.g. clays containing 25 - 50 per cent aluminum oxide) to a high purity metal via carbothermic and chlorination processing. Several research groups are studying these new methods for metal production along with alternate routes for the extraction and purification of alumina. This electrothermic smelting reaction must be carried out at a temperature of 1200°C - 1400°C, which requires special materials of construction for the commercial reactor system.

Alternate sources of alumina, as well as new reduction routes to metal, are needed to take advantage of domestic clay deposits and/or to reduce the capital expenditure. If the plant investment could be lowered from $975 to $500 per annual ton of metal, then the depreciation charge would be lowered by $20 per ton or one cent per pound of primary metal. As the gross North American output of metal is now 3.5 million annual tons and is forecast to reach 5.0 million annual tons by 1970, it can be seen that a research and development program is justified with a potential annual savings of $100 million before tax. It is felt by our engineers that these high temperature pyrometallurgical techniques might begin to replace the current electrolytic reduction method by 1980 at the earliest.

Reesedale would also serve as a suitable site for the new thermochemical processes because the electric power rate would remain a controlling cost element and economical freight rates on both raw materials and primary metal might be negotiated. The geographical proximity of Reesedale to the primary aluminum metal consumers is one definite advantage of the Armstrong County site. The proposed Federal Highway Program might permit Reesedale to be competitive with other locations. For example, ocean-going vessels could dock on Lake Erie for truck hauls of only 90 miles to Reesedale. Delivery of primary metal might be expedited by truck over the proposed Interstate Highways.

2. State Income Tax - A six per cent income tax is levied by the State of Pennsylvania on the net income before tax calculated for the Federal return. Our study has indicated that a metal sales price that allows at least five cents per pound net income before tax is needed to justify the new capital investment for primary aluminum. This is equivalent to $100 per ton of primary metal, which is a nominal return on the fixed capital plant investment of ten per cent. Although this is marginal, it is typical of the competitive nature of this expanding metal industry.

The State income tax would be $6 per ton of metal for a total of $480,000 annually in the reference design plant with a capacity of 80,000 annual tons. Although the unit State income tax of 0.3 cents per pound is small, relative to other costs, it is equal to the alumina freight charges per ton of metal. Also, the unit cost of 0.3 cent per pound is about ten per cent of the electric power cost, which was based on a power rate of 3.9 mills per KWH.

Pennsylvania has liberalized its state regulations so that the depreciation allowed for corporate net income tax on new and expanded plants is 150 per cent the Federal rates. This cost reduction has been one of five measures taken to improve the industrial potential within the State. Governor Scranton has also listed the arrangements that have been made to permit 100 per cent financing for the construction of new plants from State and Regional sources (Industrial Development Groups).

As a result of these changes in policy, it is felt that a competitive situation can be established for a new aluminum smelter in Reesedale if each cost element were examined and analyzed to achieve optimum conditions. The "keystone" location of Pennsylvania and Reesedale, within the center of the densely populated metropolitan areas from the Eastern Seaboard to the Upper Mississippi Valley, guarantees an easy overnight haul to a total consumer market of 85 million people. The $10 billion Interstate Highways will eliminate objections to the terrain of Pennsylvania for economical transportation of goods.

The success of these measures has brought in many new industries to the State and, with continued effort, will be able to meet the attractive offers from other areas. It should result in expansion of the industrial base within the State, especially in the western half that includes the nine southwestern counties.

3. Overhead Expense - If pure molten aluminum metal could be delivered directly to independent extruders and fabricators, the unit cost of administration, sales, technical service, research, and general office expense might be lowered from 7.5 to 5.0 per cent of sales. One reason for this is that hot metal accounts would require essentially no service or follow-up. A 33 per cent reduction of the nominal overhead rate of 7.5 per cent of gross sales ($37.50 per ton of metal) would reduce the unit cost of metal by $12.50 per ton, or 0.625 cents per pound. The annual savings would be $1 million for 80,000 annual tons.

H. HOT METAL SHIPMENTS

In 1948 General Motors recognized that the substitution of molten aluminum (hot metal) for the primary pig form was desirable. A series of experimental development contracts were negotiated with Reynolds Metals to evaluate the advantages of using hot metal for foundry uses. A similar arrangement was made between the Ford Motor Company and Reynolds Metals in the middle 1950's. The government-sponsored expansion of the aluminum industry was combined in some cases with long term contracts between the automobile companies and the major aluminum companies to justify, not only the installation of new reduction facilities, but also the construction of adjacent casting operations. One example is the General Motors aluminum foundry that was located at Massena, New York, in the late 1950's. Another example is the Ford foundry at Lister Hill, Alabama. The contracts between the automobile and aluminum companies for hot metal were carefully designed to assure a market for a bulk of the output from the adjacent metal reduction unit without disturbing the supply of primary metal to other customers.

The geographical location of the Reesedale site will offer a distinct advantage for users of hot metal within a trucking distance of 300 miles. There are several independent extruders within the Pittsburgh and Youngstown areas that could each consume about 5,000 to 10,000 annual tons of primary hot metal. The total amount that could be shipped out as hot metal from Reesedale would be 40,000 to 60,000 annual tons, 50 per cent to 75 per cent of the reference design capacity. One example of a potential nearby customer is Pittsburgh Aluminum Alloys near Murrysville, Pa., that plans to expand its facilities from 10,000 to 15,000 annual tons during the next six months. Another example is R. D. Werner Company near Greenville, Pa., which consumes an estimated 50,000 annual tons of aluminum and is only 85 miles northwest of Reesedale.

Independent extruders purchase aluminum billets from all of the domestic and foreign primary ingot manufacturers. This maintains a stable market price and assures them of an ample supply of basic raw material. The butts discarded from the extrusion press and other aluminum scrap material are, in some cases, remelted and cast into 500-pound sows. These scrap sows are exchanged for fresh extrusion billets from the supplier of the primary metal. It is believed that the captive casting of extrusion billets is competitive with purchased billets when more than 10,000 annual tons is consumed. In addition, it offers more flexibility to the operation in the make-up of the desired range of alloys specified for certain extruded structural shapes.

Aluminum 6063 alloy is the most common extrusion composition. The 6063 alloy costs 26.3 cents per pound in comparison with 24.5 cents per pound for the 99.5 per cent pure metal. The independent extruder would be able to recycle scrap alloy and to blend it with a mixture of fresh 99.5 to 99.9 per cent hot metal, plus the necessary amounts of the alloying components. This arrangement offers definite advantages to the independent extruder because a regular supply of hot metal would require only the storage of master alloys and a minimum of purchased extrusion billets of a 4-inch to 12-inch diameter.

The ability to sell hot metal directly to a customer has advantages for the primary aluminum manufacturer. It eliminates the quality control problem during the pigging or direct chilled casting steps. Also, some of the direct labor charges are eliminated. In addition, it reduces the load on the chemical process control laboratory and the analytical laboratory for checking material in process and the multiplicity of batches released for shipment. Other advantages are lower storage, shipping, freight and sales charges. It is difficult to assign specific charges for each of these cost elements so that only a reduction in out-of-pocket or direct charges can be taken by the manufacturer. The fabricator and the manufacturer both gain by the shipment of hot metal because it eliminates all the finished product storage that involves manpower for marking, stamping, and stacking of aluminum billets.

The use of hot metal is estimated to reduce the cost of manufacturing aluminum at least $20 per ton, or one cent per pound of primary aluminum. The original contracts between the automobile companies and the aluminum companies included pick-up and haulage of hot metal from the reduction plant to the foundry to be paid by the automobile company. This allowed a discount of 10 per cent on the aluminum content of the shipment, or about 2.0 to 2.5 cents per pound of metal, depending upon the published market price.

Recently the Chrysler Company signed a contract with Kaiser Aluminum & Chemical Company to haul hot metal 300 miles from Ravenswood (West Virginia) to its Kokomo (Indiana) foundry. The average usage of aluminum in automobiles has doubled since 1955 from 35 to 70 pounds per car. This average usage might reach 100 pounds per car by 1970. Thus, the automobile segment of the transportation industry is expected to consume at least 500,000 tons of aluminum per year - about 15 per cent of the estimated domestic primary metal output in 1970.

I. RETURN ON CAPITAL INVESTMENT

1. Background - During the middle 1950's the aluminum industry was expanded with government assistance to overcome the acute shortage of metal. One reason was to build up an adequate government stockpile for future national emergencies. Certificates of necessity for new facilities were issued by the government and contracts were drawn up by the appropriate government agencies to purchase large quantities of primary aluminum ingot. Another reason, however, for the government-sponsored expansion program was to guarantee an adequate supply of primary aluminum ingot to the multiplicity of small business concerns engaged in the fabrication of aluminum and aluminum alloy products. This expansion program also assured the non-integrated aluminum companies of a competitive purchase price for the primary metal.

Until 1958 only three companies - Alcoa, Kaiser and Reynolds - operated aluminum reduction facilities in the United States. Aluminium Company of Canada (ALCAN) was not only a major supplier of primary metal, but also was considered the chief source of metal for the independent fabricators in the United States. As a result of the government-sponsored expansion program, three additional domestic primary metal producers were added - Anaconda, Harvey and Ormet (Olin Mathieson and Revere Copper & Brass).

The projected growth rate for aluminum failed to materialize and there was an excess supply of primary aluminum ingot until the fourth quarter of 1964. It was evident however, since 1962 that demand was catching up with the supply and a small plant was built in Tennessee by Consolidated Aluminum Corporation. Anaconda started a third line at its Columbia Falls installation. Harvey Aluminum announced that it was looking for a plant site for reduction of the output from its alumina refinery in the Virgin Islands, and INTALCO started building a unique reduction plant to be located near Bellingham, Washington.

All new reduction facilities installed since 1955 have been located, essentially, in the Ohio River Valley with the exception of the three new plants in the Pacific Northwest. ALCOA selected the Warrick (Indiana) site because it was adjacent to a company-owned coal field and to its new rolling and extrusion mill. ALCOA has planned to install five potlines ultimately at this site with the second line due to come on stream in 1965 and the third in 1966. ALCOA has announced that a new site in the Ohio Valley will be selected for its next aluminum smelter.

The selection of the Warrick site was equivalent to the plant locations selected by Kaiser and Olin during the 1955-58 expansion program. These are adjacent to mine-mouth, coal-fired, steam-electric plants, and are also water side plants to accommodate barge shipments. This type of site is preferred under the present marketing conditions because it affords the optimum operating cost and is close to the center of aluminum consumption in the United States (a triangle formed by Pittsburgh, Cincinnatti, and Cleveland, Ohio).

Reynolds Metals has been revising and rebuilding its existing facilities as part of a three-year program to increase its over-all annual output by 12 per cent, for a total capital investment of $140 million. Reynolds has the largest domestic bauxite mining operation so that emphasis is usually placed on new alumina facilities before the electrolytic reduction lines are modified or increased. Reynolds recently has announced a new aluminum smelter to be located at an undisclosed site in Kentucky with adjacent captive coal reserves. This additional reduction facility confirms our recommendation that the coal-bearing regions of the Upper Appalachia offer the best combination of factors for installation of a new aluminum reduction Plant. Thus, Reesedale is considered a logical plant site for an aluminum smelter and a financial analysis of its potential is described in this section.

2. Outline of Basic Cases - The following cases have been assumed to show the different conditions under which an aluminum reduction facility can be operated. These conditions control the primary cost elements, which are the basic raw material, alumina, and electric power. In particular, the disadvantages of purchased alumina will be emphasized by the effect of the depletion allowance. Also, the possible benefit of a private power plant in comparison with the purchased power from a public utility will be illustrated.

CASE A - Reference Design - 80,000 annual tons.
Delivered Sales Price - 24.5 cents per pound.
Ownership Equity - 100 per cent.
Purchased Alumina - $65 per ton.
Purchased Power - 3.9 mills per KWH.

CASE B - Same as Case A, except captive alumina with a 15 per cent depletion allowance.

CASE C - Same as Case A, except manufactured alumina from domestic clays at a value of $65 per ton with a depletion allowance of 23 per cent.

CASE D - Same as Case A, except with a private power plant. Assume conversion of captive coal with a value of 15 cents per million BTU. A 10 per cent depletion allowance will be taken for the fuel cost.

3. Symbols and Definitions

S = ns = Annual sales, $ millions.

n = Annual tons of metal sold.

s = Delivered price of metal, $ per ton.

DM = Annual cost of all direct materials. (See Page IV - 36).

DL = Annual direct labor charges.

OL = Other labor charges.

TL = Total labor charges.

PRB = Annual payroll burden. (A factor of 25 per cent of total labor is used).

P = Annual plant cost, $ millions.

P = DM + 1.25 TL + A

A = Direct plant expense.

D = Annual depreciation charge (this is 5 per cent of the fixed plant investment).

B = Annual overhead charges. (This is assumed at 7.50 per cent of the annual sales).

N = Annual interest charges on long term debt.

M = Annual manufacturing cost, $ millions.

M = P + D + B + N

FA = Freight allowance (This is based on the average of all actual shipments).

C = Delivered cost of metal, $ millions.

C = M + FA

E = Fixed capital expenditure for plant, $ millions.

W = Working capital required for operation, \$ millions.

I = Total capital investment, \$ millions

I_o = Capital supplied by owner.

I_d = Capital supplied by funded debt.

Z = Annual operating income, \$ millions. (This is the net income before tax which is abbreviated NB4T).

Z = S - C

t = Actual income tax rate, 51 per cent. (This is based on a 48 per cent federal rate and a 6 per cent Pennsylvania State tax, which are mutually deductible).

X = Annual income tax = t Z

Y = Annual net income after tax, \$ millions.

Y = (1 - t) Z = NAT

R = Annual cash flow, \$ millions.

(This is the sum of the net income after tax, plus depreciation).

R = Y + D

ROI= Rate of return on the investment, per cent.

(This is calculated by dividing the net income before tax by the fixed capital investment).

ROI= Z/E

CER= Capital earning rate, per cent.

(This is calculated by dividing the net income after tax by the total capital investment required)

CER = $Y/I = NAT/I$

T = Nominal payout time, years.

(This is calculated by dividing the total capital investment by the annual cash flow).

T = I/R

DA = Depletion allowance, $ millions.

(This is calculated by multiplying the actual cost or the market value of the depletable item by the per cent depletion that is allowed under the tax laws).

$Z' = Z - DA$

$Y' = Z - t Z'$

$R' = R + t DA$

DCF = Discounted cash flow, $ millions.

(This is calculated by multiplying the annual cash flow by the appropriate cumulative discount factor based on a given period of years at a stipulated interest rate).

DCF = $R \times F (i/y)$ = Cash flow x Present Worth Factor

$F(i/y)$=The present worth factor prepared from compound interest tables for an interest (i) and a time period (y).

NPV = Net present value of the venture, $ millions.

NPV = $DCF - I$

(This is calculated by subtracting the investment from the present worth of the project. If the NPV is zero, this indicates that the project has generated the original capital investment in the assumed period of time and has yielded the specified interest rate on the money invested. A positive NPV indicates that the project can recover the original capital in a shorter time period than that assumed for the calculation of the discounted cash flow. A negative NPV indicates that the interest rate assumed for discounting was too high).

N ≑ Annual interest charges on long term debt (I_d) at a specific interest rate (i').

SFD = Annual sinking fund deposit, $ millions.

(This is the amount of money that must be taken from the net income after tax and deposited regularly over a given period of years (y") at a stipulated interest rate (i") to recover the funded debt).

4. Depletion Allowance - A new independent producer is represented by Case A, which is based on purchased alumina at $65 per ton and a power rate of 3.9 mills per KWH for an annual output of 80,000 tons of primary aluminum metal. The net income before tax of $5.920 million is reduced to $2.900 million after deduction of state and federal income taxes. These give an income tax rate of 51.1 per cent for the mutually deductible 48 per cent federal tax and 6 per cent state tax.

Under Case A the return on the investment is 7.59 per cent and the capital earning rate is 3.40 per cent. A payout time of 12.9 years is needed to recover the fixed capital expenditure of $78 million plus $10 million working capital for a total investment of $88 million for this project.

Case B illustrates the situation if an existing integrated aluminum company were to consider Reesedale. Then a depletion allowance of 15 per cent could be applied to the captive alumina reduced to metal. For alumina valued at $65 per ton, the annual depletion allowance would be $1.5 million. The net income after tax is increased by an amount equal to 51 per cent of the depletion allowance, or $0.760 million. This gives a 4.16 per cent capital earning rate and a payout time of 11.6 years (see Table E on Page V-67).

Alumina manufactured from domestic clays (Case C) can compete with captive alumina because a higher depletion allowance (23 per cent vs 15 per cent) can be applied. An additional capital expenditure of $35 million is needed, however, along with an extra $5 million working capital (see Table D on Page V-66). The estimated savings increase the operating income to $8.170 million in comparison to $5.920 million for purchased material. A payout time of 11.8 years shows that a manufacturing cost of $65 per ton is no better than purchased alumina. These data indicate that conversion of domestic clays cannot compete with massive deposits of foreign bauxite which are being developed to keep pace with the demand for aluminum.

Of specific interest to Reesedale is Case D, which assumes captive power generation with coal available at the equivalent of 15 cents per million BTU. The annual fuel cost would be $1.730 million based on 16,000 KWH per ton of metal and a 9,000 BTU per KWH thermal requirement. A 10 per cent depletion allowance is relatively insignificant in comparison with the estimated direct cost reduction from $5 million to $3.150 million for power - equivalent to an estimated power rate of 2.46 mills per KWH. An additional investment of $22 million is required and the total investment of $110 million is paid off in 12.3 years. This case shows that private power is only slightly better than purchased power at 3.9 mills per KWH.

5. Ingot Sales Price - From Case A in Table D (see Page V-66) it can be shown that the "break-even" sales price is 20.8 cents per pound. This permits recovery of all direct, "out-of-pocket" charges of 16.0 cents per pound incurred at the plant level. Depreciation and overhead charges amount to 4.3 cents per pound. A freight equalization charge of 0.5 cent per pound is also included.

A sales price of 24.5 cents per pound ($490 per ton) of primary ingot was assumed in all cases so that the annual sales volume of $39.2 million represents the current market price. The sequence of one-half cent incremental increases in the ingot price over the four quarters of 1964 was needed to improve the financial status of the aluminum industry. Further increases might be made before the current one billion dollar expansion program is completed over the next five years to permit an annual growth rate of at least five per cent.

The sales price and other cost elements will be examined in more detail by discussion of net present value (present worth minus total investment) in Section V-J (see Page V-68). Emphasis will be placed upon the delivered cost of alumina, power rate, depletion allowance, freight allowance, and plant capacity to illustrate the interaction of all cost elements depending upon the type of producer, the geographical location of plant relative to source of raw materials and the market area served.

TABLE D

REESEDALE ALUMINUM SMELTER

DELIVERED COST OF METAL
OUTPUT 80,000 ANNUAL TONS

ITEM (a)	Millions of Dollars Unless Specified CASE A (e)	CASE B	CASE C	CASE D
Al_2O_3	10.000	10.000	2.000 (d)	10.000
KWH	5.000	5.000	5.000	1.730 (b)
Auxiliaries	5.762	5.762	5.762	6.086 (c)
DM	20.762	20.762	12.762	17.816
DL	1.252		4.000 (d)	
OL	1.944			
PRB	0.800			
A	0.822	4.818	4.818	4.818
Sub-Total	4.818	4.818	8.818	4.818
P	25.580	25.580	21.580	22.634
D	3.900	3.900	5.650	5.000
N	None	None	None	None
B	3.000	3.000	3.000	3.000
Sub-Total	6.900	6.900	8.650	8.000
M	32.480	32.480	30.230	30.634
FA	0.800	0.800	0.800	0.800
C	33.280	33.280	31.030	31.434

(a) For definition of symbols see Pages V-59, 60, 61.

(b) Assumed fuel cost of 15 cents per million BTU.

(c) Added $0.324 million for operating and maintenance.

(d) Estimated for conversion of clay to alumina.

(e) See Page V-58 for description of four cases.

TABLE E

REESEDALE ALUMINUM SMELTER

COMPARISON OF FINANCIAL RETURN
OUTPUT 80,000 ANNUAL TONS

ITEM [(a)]	Millions of Dollars Unless Specified CASE A [(b)]	CASE B	CASE C	CASE D
E	78.000	78.000	113.000	100.000
W	10.000	10.000	15.000	10.000
I	88.000	88.000	128.000	110.000
S [(c)]	39.200	39.200	39.200	39.200
C	33.280	33.280	31.030	31.434
Z	5.920	5.920	8.170	7.766
DA	None	1.500	2.300	0.173
Z'	5.920	4.420	5.870	7.593
X'=0.51Z'	3.020	2.250	3.400	4.280
Y'=Z-X'	2.900	3.670	5.570	4.286
D	3.900	3.900	5.650	5.000
R'=Y'+D	6.800	7.570	11.220	9.286
ROI, %	7.59	7.59	7.05	7.77
CER, %	3.40	4.16	4.05	3.54
T, Years	12.9	11.6	11.8	12.3

(a) See Pages V-59, 60, 61 for definitions.

(b) See Page V-58 for description of four cases.

(c) Annual sales based on 24.5 cents per pound.

J. NET PRESENT VALUE

1. Applied to Basic Cases - This technique requires calculation of the discounted cash flow (see Page V-61) or present worth of a project to determine if the capital recovery can be made within a given time period (y in years) and at a specific interest rate (i). The nominal payout time is calculated without discounting the annual cash flow. Management uses the net present value (NPV) as one of many criteria to judge the commercial potential of alternate processes or projects before capital funds are allocated and released for operating facilities.

There is intense competition in the metals industry, not only within each segment (e.g. aluminum), but also with other metals and materials for a product area (e.g. food containers). A realtively low return on the invested capital is characteristic of the metals industry. As a result, it is usually necessary to rely on long term debt for expansion of the manufacturing facilities.

A summary of net present values shows that the same ranking of the four cases is derived as was found by the use of nominal payout time in Table E (see Pages V-67 and V-69). Also, the negative NPV of $1.0 million for captive alumina shows one combination of the primary cost elements (Case B) utilizing depletion allowance to yield a 5.9 per cent return on the invested capital:

ITEM	Millions of Dollars CASE A	CASE B	CASE C	CASE D
Z	5.920	5.920	8.170	7.766
DA	None	1.500	2.300	0.173
Y	2.900	3.670	5.190	3.896
D	3.900	3.900	5.650	5.000
R	6.800	7.570	10.840	8.896
DCF[(a)]	78	87	125	102
I	88	88	128	110
NPV	(10)	(1)	(3)	(8)
T, Years	12.9	11.6	11.8	12.3

(a) DCF = Discounted Cash Flow, in which the annual cash flow (R) is multiplied by the discount factor, F(6/20). In this case the discount factor (F) is 11.5 for 20 years at six per cent interest. This is the minimum return that can be assumed for an industrial venture to pay a dividend above that for a high-grade bond or preferred stock.

2. Price of Primary Aluminum Ingot - Over the last ten years the lowest quoted market price of ingot was 22.6 cents per pound (in 1963). There was considerable discounting, however, with many transactions reported at 18 to 20 cents per pound. There was no price increase until demand approached supply and accumulated metal inventories were eliminated late in 1964.

A sales price of 26.25 cents per pound for primary metal is needed to yield an 8 per cent return after tax. The relatively high investment of about $750 per annual ton of metal requires a high funded debt to obtain adequate capital for building new aluminum reduction facilities. Thus, the aluminum companies have emphasized revising and rebuilding existing reduction facilities until demand for metal will justify new plants.

The dependence of NPV upon metal sales price can be illustrated for Case B with increments of one penny per pound of metal sold:

ITEM		Metal Price, ¢/lb.		
	24.5[a]	25.5	26.5	27.5
DCF[b], $ Millions	87	96	105	114
NPV(6/20) "	(1)	8	17	26
DCF[c] "	74	82	90	97
NPV(8/20) "	(14)	(6)	2	9
DCF[d] "	65	72	79	85
NPV(10/20) "	(23)	(16)	(9)	(3)

(a) See Case B on Page V-58.

(b) Factor (6/20) is present value factor for a 6 per cent interest rate over 20 years. F(6/20) is 11.5.

(c) Factor (8/20) is 9.82

(d) Factor (10/20) is 8.61

3. Alumina Source - This is the primary cost element so that its availability under a long-term contract is imperative for purchased material. Foreign deposits have been developed and exploration work has uncovered suitable new foreign reserves to maintain the exceptional growth pattern

of the aluminum industry.

The effect of incremental changes of $10 per ton in the delivered price of purchased alumina without depletion allowance is:

	Delivered Cost of Alumina, Per Ton			
	$45	$55	$65[(a)]	$75
DCF, $ Millions (b)	95	87	78	70
NPV, $ Millions (c)	7	(1)	(10)	(18)

(a) Case A assumed alumina at $65 per ton.

(b) Discount factor is 11.5 for F(6/20).

(c) Total investment is $88 million.

Thus, a delivered price for pure alumina of $53.75 per ton would be necessary for zero net present value or for the investment to yield six per cent annually over 20 years. A price of $45 per ton of delivered alumina shows a positive NPV of $7 million. A price of $75 per ton shows a negative NPV of $18 million.

It can be seen from this comparison that INTALCO needs a foreign source of alumina in order to compete with the domestic suppliers. Also, it shows the unfavorable financial position of Anaconda when delivered alumina costs about $75 per ton.

4. Power Rate - With Bonneville Power Authority granting a power rate of 1.7 mills per KWH in some locations, the

effect of this cost element on the NPV is of interest:

	Power Rate, Mills per KWH 1.7	2.2	3.3	3.9[a]
DCF, $ Millions (b)	94	91	82	78
NPV, $ Millions (c)	6	3	(6)	(10)

(a) Case A was based on this assumed power rate for Reesedale.

(b) Discount factor is 11.5 for F96/20).

(c) Total investment is $88 million.

Thus, location of a plant in the Pacific Northwest, where it will be possible to purchase power at 2.2 mills per KWH, is equivalent to an increase in NPV of $13 million over the Reesedale site. For domestic alumina from the Gulf Coast, however, this positive NPV would be reduced by $9 million to cover the extra rail freight charges. For Australian alumina, however, the overland freight for ingot from the Pacific Northwest to Pittsburgh would reduce the NPV by $11.3 million for delivery of ingot to Pittsburgh. Thus, the Reesedale site should be able to compete with the Pacific Northwest at a power rate of 3.9 mills per KWH.

5. Long Term Debt - The federal and state income tax regulations allow interest charges to be deducted as an indirect operating expense. This becomes a beneficial cost element when the funded debt is 25 to 50 per cent of the

total capital investment.

During the last 10 to 15 years a special case has been established whereby municipal bonds are issued to cover the total capital requirement for an industrial project. The industrial concern pays an annual leasing fee to cover the interest charges and the sinking fund deposit plus any incidental handling charges. The contract then allows the industrial tenant to acquire the plant at the end of a 20 to 22-year period under a lease-purchase clause.

These municipal bond financing plans are unique because they represent $50 to $55 million projects and the bondholders are permitted to retain the full amount of the tax-free interest (as high as five per cent). In addition, it allows the industrial concern to accumulate surplus earnings as a capital reserve.

The benefit of the use of funded debt is presented in Table F (see Page V-74). A sales price of 25.0 cents per pound of aluminum was used for this set of calculations with Case B as reference.

Thus, in Case B, the availability of long term debt money is equivalent to an additional $36 million in the NPV for the extreme case (municipal bond financing) of zero equity. Most of the aluminum companies carry 25 to 50 per cent of capitalization as long term debt. This is desirable

TABLE F

REESEDALE ALUMINUM SMELTER

EFFECT OF FUNDED DEBT ON NET PRESENT VALUE
OUTPUT 80,000 ANNUAL TONS

ITEM	Equity 100%	Equity 75%	Equity 50%	Equity 0%
	Millions of Dollars Unless Specified			
I_o	88.000	66.000	44.000	Zero
I_d	None	22.000	44.000	88.000
N (5%)	None	1.100	2.200	4.400
C	33.280	34.380	35.480	37.680
Z	6.720	5.620	4.520	2.320
DA	1.500	1.500	1.500	1.160
Z'	5.220	4.120	3.020	1.160
Y	4.060	3.520	2.980	1.730
SFD (5/20)	None	0.520	1.110	2.110
Y'	4.060	3.000	1.870	(0.380)
R	7.960	6.900	5.770	3.520
DCF (6/20)	93	80	67	41
NPV	5	14	23	41
t (b), %	39.5	37.5	34	-

(a) Case B used as reference with 15% depletion allowance.

(b) Effective income tax rate.

because it increases the annual cash flow by an amount equal to the interest charges multiplied by the tax rate.

Case B (see Page V-58) was chosen for the effect of long term debt because it includes 15 per cent depletion allowance. This was calculated on a cost of $65 per ton of alumina consumed. Under these conditions the effective tax rate is 39.5 per cent. It must be pointed out, however, that the actual effective tax rate calculated from data in the annual reports of the integrated aluminum companies is about 32 per cent. It is believed that the integrated companies might calculate depletion allowance on the basis of the aluminum ingot market value contained in their fabricated items. The market value of either alumina or metal will be difference, however, for each company because it must be established by the procedures employed for distribution of fixed charges and the transfer price selected by company management.

These cost studies have illustrated the importance of not only the direct plant operating costs, but also the indirect charges combined with the advantages of depletion allowance and interest on long term debt. In the metals industry and, in particular, the primary aluminum segment, it is evident that the ability to borrow money and depletion allowance are critical. A successful entry into the aluminum business will require a competent team of financial and technical personnel to achieve the desired financial return for the large sum of fresh capital invested.

K. PLANT CAPACITY

Only two of the three proposed 40,000-ton lines have been considered in our reference design for Reesedale. The space for the third 40,000-ton line will be available for future expansion to an annual output of 120,000 tons of primary aluminum. The ultimate requirement of primary metal might reach 240,000 annual tons. The effect of annual output from the Reesedale smelter can be seen from a summary of the cost data:

	Output of Metal, Annual Tons			
ITEM	40,000	80,000(a)	120,000	240,000
I, $ Millions	66	88	117	200
DCF, "	38	87	135	262
NPV, "	(28)	(1)	18	62

(a) Use Case B on Page V-66 for reference.

(b) Use F(6/20) = 11.5.

These data show that it would be desirable to build a smelter in the southeastern Pennsylvania area with an annual capacity of 240,000 tons.

L. COMPARISON OF REESEDALE WITH PACIFIC NORTHWEST

The combined effect of plant capacity, delivered cost of alumina, power rate, and freight allowance for aluminum ingot is shown in Table G on Page V-78. An integrated producer was assumed considering southwestern Pennsylvania and the Pacific Northwest as suitable plant sites. The desired plant capacity is 120,000 tpy of aluminum selling at 24.5 cents per pound.

It can be seen that the market distribution of the aluminum becomes the controlling cost element when considering the Pacific Northwest area. A smelter in this region shipping its entire output to a captive rolling mill in the Middle Atlantic region will be a "break-even" situation with a smelter at Reesedale. When Columbus, Ohio, is used as the destination of the ingot, however, the Pacific Northwest will have a slight advantage. The reduction in the ingot freight rate by $10 per ton increases the yield from 9.0 to 9.7 per cent on the estimated $117 million investment.

Thus, each of these primary variables must be studied in detail and the market pattern must be well established before a reliable decision can be made on the optimum location for a smelter. In addition, the secondary cost factors of plant expense, sales expense, and corporate expense can also influence the overall operating cost for a producer.

TABLE G

COMPARISON OF REESEDALE WITH PACIFIC NORTHWEST

Note: An integrated producer was assumed in all cases and a 15% depletion allowance taken on alumina.

ITEM*	Case B0	Case B1	Case B2	Case B3
n, TPY	80,000	120,000	120,000	120,000
s, ¢/lb.	24.5	24.5	24.5	24.5
S, $million	39.200	58.800	58.800	58.800
E, $million	78	102	102	102
W, $million	10	15	15	15
I. $million	88	117	117	117
Al_2O_3, $/Ton	65	65	55	55
KWH, mills	3.9	3.9	3.9	2.2[a]
FA, $/Ton	10	10	10	35[b]
M, $million	32.480	46.366	44.066	40.806
FA, $million	0.800	1.200	1.200	4.200
C, $million	33.280	47.566	45.266	45.006
Z= S-C	5.920	11.234	13.534	13.794
DA	1.500	2.250	1.900	1.900
Zo= Z-DA	4.420	8.984	11.634	11.894
X = .51 Zo	2.250	4.590	5.910	6.080
Y = Z-X	3.670	6.644	7.624	7.714
D	3.900	5.100	5.100	5.100
R = Y + D	7.570	11.744	12.724	12.814
DCF = 11.5R	87	135	146	148
I	88	117	117	117
NPV = DCF-117	(1)	18	29	31
Yield[c]	5.9%	7.8%	8.9%	9.0%

* See page V-59 for definition of symbols. All cases are for Reesedale except Case B3.

a-Bonneville Power Authority reports a power rate of 2.2 mills/KWH - 3.9 mills/KWH was assumed for Reesedale.

b-FA=Freight allowance to eastern Pennsylvania.

c-The equivalent annual return on investment over 20 years.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. Growth Rate of the Aluminum Industry - Since the last quarter of 1964, all of the domestic reduction facilities have been operating at full capacity with a nominal output of primary aluminum metal of almost 2.6 million tons per year. During the first six months of 1965 additional potlines have been added to existing plants and new reduction facilities have been authorized to increase the total domestic primary aluminum metal capacity by 350,000 annual tons before January 1, 1967.

In order to meet the projected growth rate of 5.2 per cent for the aluminum industry, it is estimated than an additional investment of $1 billion will be required to provide the facilities for bauxite mining, alumina refining, reduction to metal and fabrication for increasing the annual capacity by another 650,000 tons. At least $1.5 billion in private funds will be expended to add a total of one million tons to the annual capacity by 1970-72. By the year 2000, the annual output of domestic aluminum reduction facilities is expected to reach 12.0 to 13.0 million tons.

The outstanding growth rate of the aluminum industry is expected to remain above or at least be equal to that of the gross national product. The United States produces nearly one-half of the total free world aluminum output. Canada produces 15 per cent, Europe produces 25 per cent and the rest is made in Australia, Japan, Africa and Brazil. In the past there has been more metal imported than exported from the United States, but this characteristic is changing rapidly despite the construction of new reduction and fabricating facilities throughout the free world.

2. Market Proximity of Reesedale - Reesedale is situated in a unique geographical location to supply all forms of primary metal to the diversity of customers within the industrial northeast quadrant. In particular, the Reesedale site offers a short haul of hot metal to large independent extruders located within 50 to 400 miles of the proposed smelter. In addition, Reesedale is conveniently located to serve large plants and complexes in the transportation equipment field, building materials, consumer durables, and packaging materials.

The Interstate Highway System will include several new express routes that will be accessible from Reesedale. The proposed Interstate Highway 80 will give Reesedale preferential advantage over other locations in the shipment of ingot or hot metal to all points within overnight trucking distance.

Thus, Reesedale will be able to service customers located along the Middle Atlantic seaboard, in the lower New England States, throughout the Mohawk Valley, and in the area to the west bounded by Cleveland, Detroit, Cincinnati, and Pittsburgh.

It is believed that Reesedale will also have greater flexibility than other inland locations because it can receive inbound materials from the Gulf Coast by river barge, from the port of Baltimore by rail, and from the new Conneaut dock (Ohio) on Lake Erie by rail. This ability to accommodate any form of traffic for both inbound raw materials and outbound ingot, cannot be matched by plant sites in the middle and lower Ohio Valley.

3. Financial Analysis - Our cost studies have shown that it would be difficult for a new independent producer to enter the primary aluminum field unless the smelter was designed for an annual capacity of 120,000 tons of ingot. By a discounted cash flow analysis under current conditions an independent smelter with a capacity of 120,000 tpy would show a nominal yield of 6.5 per cent on the $117 million investment over a 20-year period in comparison with 4.80 per cent on $88 million for a capacity of 80,000 tpy. The increased output reduces the unit costs for total labor, direct plant expense, depreciation and overhead.

An established integrated producer of aluminum will show a higher return, however, because a tax benefit is granted in the form of depletion allowance for the manufacture of captive alumina. For an ingot sales price of 24.5 cents per pound, an alumina price of $65 per ton, a power rate of 3.9 mills per KWH, and an overhead factor of 7.5 per cent sales, the integrated producer will show a marginal yield of 5.9 per cent on the investment for 80,000 annual tons of metal and an acceptable yield of 7.9 per cent for 120,000 annual tons.

A direct comparison of the Reesedale area with the Pacific Northwest has been made in Table G on page V-77 for an integrated aluminum company. The low power rate of the Bonneville Power Authority (2.2 mills per KWH) is offset by the added ingot freight rate. It was assumed that captive alumina can be delivered to either plant at $55 per ton. It is evident that Reesedale will be able to compete with the Bonneville area because the source of captive alumina will be either the Gulf Coast or the Caribbean. It is a longer haul to the Pacific Northwest from either of these alumina sources or from Australia. Reesedale has another geographical advantage in that it is located closer to the center of aluminum consumption, Columbus, Ohio.

4. Private Power - From our cost studies it appears

that the additional capital requirement for a private power plant will yield 6.5 per cent on the investment. These funds will show a yield of 12.0 per cent, however, if used for increasing the capacity of the smelter with purchased power at 3.9 mills per KWH.

5. Manpower - The reference-design smelter would employ 430 people (annual payroll $3.196 million) at 80,000 annual tons and 532 people ($3.870 million annual payroll) at 120,000 annual tons. Aluminum reduction experience would be required for only a few of the plant staff because special training programs would be carried out for all supervisors, foremen and operators prior to plant start-up.

6. New Processes - Anaconda has announced that an alumina-from-clay plant will be constructed in Georgia to treat the local kaolin-rich clays. This wet extraction procedure will follow those used for uranium and other rare metals. It has been under development by Anaconda for over 10 years. It is felt that this new Anaconda process will be able to compete with purchased alumina made by the Bayer process.

It should be noted that clays of the upper Ohio Valley were examined intensively for several years in the laboratory by the ORMET Corporation and the North American Coal Company. A feasible process was not found so that the project was abandoned.

A few new alternate smelting schemes for aluminum have been announced by some of the primary aluminum producers. A direct carbo-thermic reduction is one approach to reduce the fixed capital investment by one-half. Essentially all of the new capital expended, however, is for installation of the established Hall-Heroult process with improvements.

B. RECOMMENDATIONS

1. Potential Clients

One of the integrated aluminum companies should investigate not only Reesedale but also other suitable sites in southwestern Pennsylvania that will allow both the smelter and the power plant to be located on adjacent sites or within a distance of 15 miles. The aluminum company should be able to justify a minimum initial capacity of 120,000 tons per year and an ultimate capacity of 240,000 tons per year.

This annual output is needed to negotiate an acceptable and preferential power rate with a utility company based on an eventual load of 500 megawatts. It is felt that cost elements other than the power rate, however, probably contributed to the decisions by both ALCOA and REYNOLDS to build their next smelters in the upper Ohio Valley near captive coal deposits.

The Reesedale area affords an excellent geographical advantage for an aluminum smelter to supply the regional market represented by the northeast quadrant of the United States. Access to this market will be improved when Interstate Highway 80 is completed. It will then be convenient to ship ingot and hot metal for both captive and merchant users within a trucking distance of 400 miles.

The availability of hot metal will strengthen the long-term potential of a Reesedale smelter. There are several independent extruders in western Pennsylvania, northern Ohio, and southeastern Michigan that now consume over 80,000 annual tons of aluminum. Location of a smelter in southwestern Pennsylvania will encourage the expansion of fabricating industries in western Pennsylvania and the nearby areas.

2. Alumina Supply

The installation of suitable receiving, handling and storage facilities should be investigated for a Middle Atlantic port such as Baltimore. Facilities to accommodate 240,000 to 480,000 annual tons of alumina are needed to permit trainload shipments to compete with barge transfer from the Gulf Coast to the Reesedale area. These facilities could also handle high purity minerals, e.g. refractory-grade bauxite.

applicable for processing Pennsylvania clays to manufacture alumina at a cost equivalent to or below that for purchased material - about $65 to $70 per ton.

Anaconda has announced that the first private alumina-from-clay plant will be constructed in Georgia to treat the kaolin-rich local clays. The procedure is presumably based on a hydrochloric acid leach to separate the insoluble silica, an open-steam stripping to recover the hydrochloric acid, a separation technique to remove the iron contaminant, and final calcination to the pure alumina. This new wet extraction procedure follows, in general, those developed for uranium recovery from low-grade ores that are now being applied to extraction of other metals.

A dual coal-clay mining operation has the advantage that the processing of the clay will lower the mining cost of the coal by assigning a portion of the operating cost to the alumina values in the clay. Each ton of primary metal requires six tons of coal and 10 to 12 tons of clay (30 per cent alumina). Thus, suitable massive deposits of coal-clay seams for either stripping or underground mining must be found to yield annually at least one million tons of coal and two million tons of clay. Each of the 1000-plus megawatt power stations planned for the coal-rich region east of Reesedale will require about three million tons of coal each year. These mining operations will suffice to feed an alumina refinery either at the mine site or at Reesedale.

Of course, there are many amenable clay deposits within the Appalachia Region, which includes Georgia, so that demonstration of a commercial process by Anaconda will undoubtedly be a precursor of similar units for recovery of alumina.

The availability of salt at an elevation of 6000 feet below the surface has been examined as a source of caustic-chlorine in another Phase III Report. This would be suitable for the generation of the hydrogen chloride required to leach the alumina-bearing clays.

5. Potential Clients - Several of the integrated aluminum companies might find Reesedale a suitable site to supply primary metal to their captive rolling and fabricating facilities in the northeast quadrant during the expansion contemplated for the next five to ten years. In addition, some of the non-integrated aluminum producers, along with some of the major independent aluminum fabricators (especially those in the Pittsburgh, Cleveland, Buffalo triangle), will find Reesedale an appropriate smelter site.

6. New Smelting Techniques - Several alternate aluminum smelting schemes are being studied intensively as potential future replacements for the Hall-Heroult Process. Carbothermic reductions of a high-grade alumina ore must be

followed by a refining step. The primary objective is to develop a direct reduction process that will reduce the fixed capital expenditure by a factor of two. In general, it was concluded that there is significant opportunity to improve the current reduction operation to increase productivity, to lower direct operating costs, and to make a purer metal (e.g. 99.8 per cent aluminum).

B. RECOMMENDATIONS

1. Alumina Supply - It is recommended that a traffic specialist prepare a detailed analysis to determine the conditions under which rail shipments of alumina to Reesedale can compete with barge transfer from the Gulf Coast. Our studies have indicated that suitable receiving and storage silos are needed at the port of entry, for example, Baltimore, Maryland, or Conneaut, Ohio. A fleet of about fifty 100-ton covered hopper cars must also be made available to transfer the alumina in minimum trainload lots of 1000-ton from the deep water port to Reesedale. The capital expenditures required for receiving, handling, and transporting the pure alumina might be provided by public funds because the equipment will have general utility for other high purity materials that are imported, for example, refractory-grade bauxite.

A detailed engineering study is suggested to compare the conversion of imported bauxite to alumina with the purchase of pure alumina. Reesedale alumina from imported bauxite is not competitive with purchased metal-grade alumina. This situation might change, however, if a suitably low freight rate could be established for transferring the raw bauxite ore from the mine site to a Lake Erie dock and then to the Reesedale site. In addition, adequate supplies of captive caustic soda could be derived at Reesedale by electrolysis of salt from the local deposits.

2. Coal and Clay Deposits - A complete examination of all available diamond drilling tests near Reesedale should be made by a reputable team of geologists. The purpose of this survey, which might include some corroborating core drilling tests, would be to define the geological formations and the mineralogical characteristics of the coal beds and clay underlays within 50 to 100 miles of Reesedale. Once a suitable deposit of coal and clay had been selected, actual mining costs could be estimated. Also, amenability tests could be run on the clay samples in the laboratory for conversion to alumina so that a reliable engineering analysis could be prepared.

If the laboratory work and engineering study showed promise, then a suitable pilot plant could be installed to determine which of the extraction methods was preferred for conversion of the clay to pure alumina. A versatile research and development facility might be financed out of capital funds supplied by the Pennsylvania Industrial Development Authority.

Another possible advantage of treating the Pennsylvania clays for recovery of pure alumina is that the Pennsylvania refractory industry specializes in high-duty furnace materials for the steel industry. At present the refractory furnace linings for the oxygen steel making process are in short supply. This condition is expected to continue for several years until the optimum material of construction has been found for this new steel process.

3. Market Survey - A detailed survey is recommended of the integrated and independent fabricators that could be conveniently served by the Reesedale site. There are indications that there are a few large extruders within a short haul of Reesedale who might consume a combined total of 40,000 annual tons of hot metal at the present time. Of course, there are many details to be worked out before delivery of either billet or hot metal is established as the optimum form of primary aluminum for a given metal-forming operation. The annual savings must be based on a reliable process analysis for a given set of market requirements - alloy composition, delivered price, and form of primary aluminum metal needed.

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